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SCIENCE BULLETIN

TICKS OF THE NEVADA TEST SITE

by

D Elden Beck, Dorald M. Allred
and Elias P. Brinton

Biological Series — Vol. IV, No. 1

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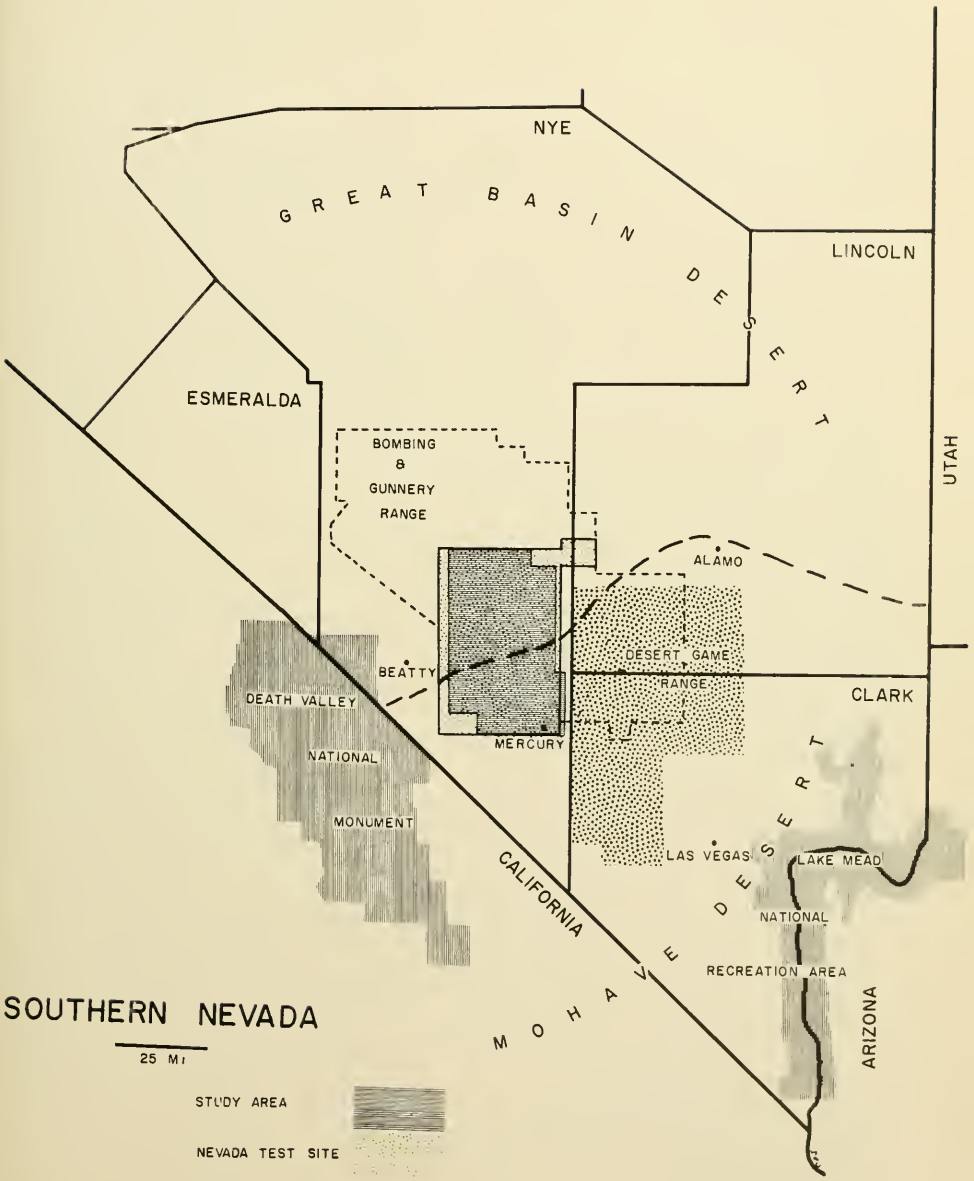

Fig. 1 Map of Southern Nevada

TICKS OF THE NEVADA TEST SITE

INTRODUCTION

This report on the tick fauna of the Nevada Test Site is one of the series of publications resulting from ecological studies conducted by the Brigham Young University Department of Zoology and Entomology in cooperation with the United States Atomic Energy Commission.[1] The principal objectives of the over-all project were maintained in this study, namely, to determine kinds, population, seasonal occurrence, and geographical and ecological distribution of ticks in areas where nuclear detonations have taken place compared with undisturbed areas. (For a detailed account of the over-all project and description of the general ecology of the area, see "Biotic Communities of the Nevada Test Site" by Allred, Beck and Jorgensen, 1963a.)

Published accounts of ticks collected in Nevada are for the most part instances of isolated collections, such as reported by Cooley and Kohls (1944), Philip, Bell and Larson (1953), Parsons (1947), and Allen (1960). As far as is known, our report is the first which deals with a periodic collection of ticks in a specific area of that state.

METHODS AND PROCEDURES

Although the tick collections were a by-product of studies of the mammalian fauna, especially the rodents and leporids, they were not incidental. A planned set of procedures and methods involving examination of each host for all kinds of ectoparasites, including ticks, was followed.

Rodent hosts were obtained by two trapping methods, and all specimens thus taken were placed in separate paper sacks which were sealed and returned to the laboratory. Specimens trapped in live-catch traps were killed in the field and sacked or taken to the laboratory where they were killed and sacked. Those captured in break-back traps were sacked in the field. Rabbits and larger vertebrates collected by use of jaw traps, shot guns, or rifles were also placed in paper bags when possible.

The specific site where a host was collected was related to a particular plant community and reference area which enabled an identification code to be attached to each parasite collection (see "Nevada Test Site Study Areas and Specimen Depositories" by Allred, Beck and Jorgensen, 1963b).

Hosts returned to the laboratory were refrigerated for several hours and then examined in a large, white enamel pan exposed to good illumination. The ticks were obtained by brushing the fur of the host as well as close examination of its body to locate those which remained attached in places such as the ears and axillae. Some ticks readily detached from the host after the heat of illumination stimulated them. Others had to be removed with forceps. Even with care the latter method of removal resulted in broken mouth-parts of some ticks. This was especially true of species of *Ixodes*.

Ticks were preserved in glass vials containing 70 percent ethyl alcohol. Those collected from each host were kept separate and labeled with necessary coded information.

When ticks were prepared for specific indentification each collection was supplied with a reference number. This same number referred to a line of data on a collection record form (CR form) and was also entered on an identification sheet in column style after which the identifier wrote the name of the organism. Data on the CR form also included the collection code and a serial number for each collection. From the identification sheet the species name was entered opposite the same reference number on the CR form. The coded collection data were then transcribed from this sheet to IBM punch cards preparatory to computer tabulation and analysis. Computer analysis provided statistical information on host-parasite relationships, seasonal incidence and ecological distribution with reference to a previously identified plant community at the Nevada Test Site.

DELIMITATIONS

As already mentioned, the tick collections in this study were principally from rodents and leporids. Such sources naturally would not reveal all the kinds of ticks which may occur at the test site. For example, only a few nests of

[1]AEC Research Grant AT(11-1)780

the desert wood rat, *Neotoma lepida*, were examined. Although no ticks were found, the original discovery of an atypical (Davis and Mavros, 1956) soft-bodied tick of *Ornithodoros hermsi* Wheeler, Herms, and Meyer in Utah was reported from wood rat nests by Beck (1955). These specimens were first taken from wood rat nests by Allred in 1950. Since that time many collections have been made in Utah, although specimens were not found in every nest. Undoubtedly a thorough study of many wood rat nests at the Nevada Test Site would supply this and perhaps *O. talaje* or other related species.

Inasmuch as Jellison (1940) found *O. parkeri* on the burrowing owl, *Speotyto cunicularia*, and in its nests and burrows in Washington, it is possible that this tick may be present at the test site. Cooley and Kohls (1944) also reported this tick from burrows of *Sylvilagus* sp., *Citellus* sp., *Dipodomys* sp. and other rodents in Nevada. Some of these collections reported were made in southern Nevada.

Certainly when the bat fauna and their retreats at the Nevada Test Site are studied more carefully, additional records of soft-bodied ticks may be discovered.

For the most part our initial surveys were confined to the valleys and lower elevations of the surrounding mesas and mountain ranges. Surveys of vertebrates at higher elevations at the test site naturally would provide a more accurate picture of the tick distribution. For example, *Dermacentor hunteri* has been taken on the mule deer and desert bighorn sheep a few miles east of the Nevada Test Site.

Undoubtedly when a complete survey has been made of the avifauna and their parasites at the test site additional tick species will be found. This would most likely be true for the ground- and cliff-nesting species of birds.

The species of ticks and their known hosts at the Nevada Test Site are shown in Table 1.

PUBLIC HEALTH IMPLICATIONS

This study was not intended to investigate the ticks as natural reservoirs for infectious diseases or as vectors. Nevertheless, it is interesting to note that there are species of hosts and ticks present which have been so implicated. *Dermacentor parumapertus* is one of the most abundant hard-bodied ticks at the test site. Philip and Hughes (1953) reported natural infections in this tick of tularemia, Rocky Mountain spotted fever-like rickettsia, and the virus of Colorado tick fever, all of which are diseases affecting man. Workers in the University of Utah Ecological and Epizoological Research Unit at Dugway effectively demonstrated by laboratory experiments the capability of *Otobius lagophilus* as an agent of transfer and reservoir for tularemia organisms (Vest, 1957). They reported that one female retained the organisms for 611 days and nymphs for more than nine months. Stoenner, Holdenreid, Laekman, and Orsborn (1959) reported Q-fever in Utah as occurring naturally in the black-tailed jack rabbit, *Lepus californicus*, and its almost omnipresent parasite the rabbit tick, *Dermacentor parumapertus*. Both of these animals are abundant at the Nevada Test Site. The tick *Hemaphysalis leporis-palustris* was also found at the test site. Parker (1923) and Philip (1942) have shown this species of tick to be a natural carrier of Rocky Mountain spotted fever.

The above indicates a potential public health problem at the Nevada Test Site. As far as the authors know there has been no attempt to recover any disease agent from either hosts or ticks at the test site. Such a study would certainly be noteworthy.

ACKNOWLEDGMENTS

Identifications and verifications of the mammalian hosts were made by C. Lynn Hayward of the Department of Zoology and Entomology, Brigham Young University. Most of the immature ticks of the genus *Ixodes* were classified by Carlton M. Clifford and Glen M. Kohls at the Rocky Mountain Laboratory, Hamilton, Montana. The remaining determinations of immature as well as adult stages were made by the authors of this paper. Questionable adults were submitted to Clifford and Kohls for corroboration or correction.

Ticks from mule deer and bighorn sheep were kindly supplied us by Dr. Charles Hansen, Biologist at the Bighorn Game Refuge, Nevada.

In a study of this dimension and especially in view of the fact that it was associated with the larger study of the biotic communities at the test site, there were many persons directly and indirectly involved. As research associates, technicians or clerks they have been an integral part of the study, and even though the long list of names is not given here, they are gratefully recognized for the valuable part they have played.

Table 1. Host-tick associations indicated by stage of tick development[1]

Host	Tick											
	Argas persicus	*Otobius lagophilus*	*Dermacentor albipictus*	*Dermacentor parumapertus*	*Haemaphysalis l-palustris*	*Ixodes angustus*	*Ixodes kingi*	*Ixodes ochotonae*	*Ixodes pacificus*	*Ixodes sculptus*	*Ixodes spinipalpis*
BIRDS											
Anas cyanoptera Cinnamon Teal	A										
Melospiza lincolnii Lincoln's Sparrow					N						
MAMMALS											
Antrozous pallidus Pallid Bat		L									
Ammospermophilus leucurus Antelope Squirrel				LN		NA	N	L		LNA	
Bassariscus astutus Ringtail				L			N				
Canis latrans Coyote							A				
Dama hemionus Mule Deer			A								
Dipodomys merriami Merriam's Kangaroo Rat				LN	U		LN			N	N
Dipodomys microps Chisel-toothed Kangaroo Rat	A			LNA	L	A	LNA				
Dipodomys ordii Ord's Kangaroo Rat				LN							
Eutamias dorsalis Cliff Chipmunk						N		L			
Lepus californicus Jack Rabbit		N		LNA							
Microdipodops megacephalus Kangaroo Mouse							LN				
Neotoma lepida Wood Rat				L			LN				
Onychomys torridus Grasshopper Mouse		L		LN			LN				
Perognathus formosus Long-tailed Pocket Mouse				L					LN		N
Perognathus longimembris Little Pocket Mouse				LN							N
Perognathus parvus Great Basin Pocket Mouse				LN			LN		L		
Peromyscus crinitus Canyon Mouse		L									
Peromyscus maniculatus Deer Mouse				L		N	LN				
Peromyscus truei Piñon Mouse						N					
Sylvilagus audubonii Desert Cottontail				LN	LN		L				
Sylvilagus nuttallii Nuttall's Cottontail					N						
Thomomys umbrinus Pocket Gopher					N						

[1] L = larva, N = nymph, A = adult, U = stage unknown.

SPECIES DISCUSSION

Argas persicus (Oken)

Hosts. Only two females were found — one from a Cinnamon Teal and the other from a kangaroo rat.

Seasonal incidence. The tick from the duck was taken in April, and the one from the rat in June.

Comments. This species is usually listed as the "fowl tick" although it has been frequently found on native wild birds distributed worldwide in warm, dry situations. The infrequency of collection is not necessarily indicative of its occurrence at the test site. Roosting sites, nests, and the tunnels of burrow-inhabiting birds have not been systematically examined. Cooley and Kohls (1944) reported specimens collected from "nesting holes" of the Inyo Screech owl, *Otus asio inyoensis*. Its occurrence on a kangaroo rat as found in our studies is unusual. Nevertheless, other soft-bodied ticks such as *Ornithodoros turicata* and *O. parkeri* have been taken in rodent burrows elsewhere, so a thorough survey of such habitats at the test site may reveal its presence.

Otobius lagophilus Cooley and Kohls

Hosts. Twenty-eight larvae were taken from two pallid bats, two from a grasshopper mouse, 22 from a canyon mouse, one from the desert wood rat, one from the chisel-toothed kangaroo rat, 32 from the black-tailed jack rabbit, and two from the House Finch. A total of 89 nymphs was collected from the black-tailed jack rabbit.

Seasonal incidence. The earliest date for larval collections was May 18 and the latest was January 30. Some nymphs were taken in January from the jack rabbit but most were taken in April, May, June, July, August, and September with the majority between May and August.

Comments. In the original description for the species (Cooley and Kohls, 1940), a long list of collections from western United States shows about the same pattern of seasonal appearance except 10 nymphs listed from a "rabbit" in October. We have not taken specimens during this month although they may be present.

All of the ticks taken at the test site in the nymphal stage came from the black-tailed jack rabbit, *Lepus californicus*. All of the host records listed by Cooley and Kohls (1940) in the original description of the species were nymphs collected from various kinds of leporids. Typical of some species of ticks, in the larval stage *O. lagophilus* is found on a variety of hosts. Woodbury (1954) reports an unsuccessful attempt to get newly hatched, laboratory reared larvae of this species to attach to kangaroo rats. On the other hand, we have found them on the chisel-toothed kangaroo rat, *Dipodomys microps*. Of special interest are nymphs taken in June, July, and August which were shipped alive in glass, cotton-stoppered vials to the Brigham Young University laboratory for life history studies. Within five days after collection, the greatly engorged nymphs had transformed to the adult stage during transit from the test site.

Plant community relationships. As would be expected, the geographic distribution for the ticks would be determined by host distribution. The black-tailed jack rabbit is generally distributed over the test site with greatest abundance in the Grayia-Lycium community and is next most abundant in the Mixed community. Inasmuch as larvae were collected from bats, birds and several species of rodents it is obvious that much more extensive collecting must be done at the test site in order to correlate larval stage with plant communities.

Dermacentor albipictus (Packard)

Hosts. One male and three females were found on two mule deer.

Seasonal incidence. The adult ticks were collected in October.

Plant community relationships. At the test site the mule deer are found mainly in the Pinyon-Juniper community of the high mesas. They are known to migrate through the valleys, going from one mountain range to another. No doubt this tick species is relegated to the habitat of the mule deer.

Comments. This species is common on deer and elk in the western United States and occasionally infests horses and cattle. It is a one-host tick. The engorged females drop to the ground where they lay eggs in the autumn. The larvae await contact with the preferred host (the mule deer) or may over-winter. When a likely host comes along in the spring, they attach to it. Larvae once attached remain on the host, engorge and undergo developmental changes through the nymphal to the adult stage. In the

adult stage, a final engorgement takes place and the cycle is repeated.

Ticks taken in our collections were from hosts which were shot during a deer hunt. No year-round survey for these ticks has been made of the larger vertebrates at the test site, especially those at higher elevations.

Dermacentor parumapertus Neumann

Hosts. Totals of 869 larvae, 243 nymphs, and 199 adults were collected from 10 species of rodents, 44 rabbits of two species, and one species of carnivore. Larvae were most commonly encountered on kangaroo rats, pocket mice, and the black-tailed jack rabbit. Nymphs were common on kangaroo rats and were less abundant on other rodents. They were completely absent on carnivores. Almost without exception the adults were taken from black-tailed jack rabbits. Exceptions were two females collected from the chisel-toothed kangaroo rat and three males from the Golden Eagle, *Aquila chrysaetos*.

Seasonal incidence. Larvae were collected every month of the year except July (Fig. 2). The highest incidence was in February and the greatest number of hosts with larvae was in April, with kangaroo rats and the antelope squirrels predominating.

Nymphs were collected every month of the year except July and September, with the highest population in May. Average numbers of nymphs found were constant for each month, increasing slightly in April, abruptly in May, declining slightly in June and abruptly in July.

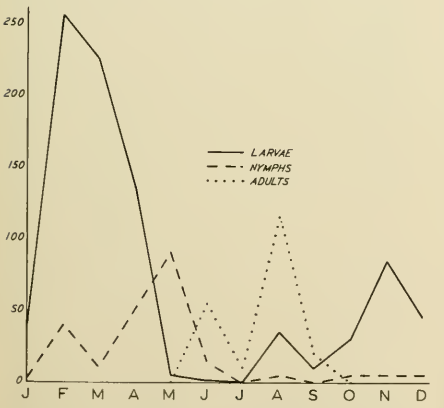

Fig. 2. Seasonal incidence of *Dermacentor parumapertus*.

Their host predominance and preference were similar to the larvae.

Adults were collected from June through September, with the highest population occurring in August. There were no systematic collections of the jack rabbit over a 12 month period at the test site. Consequently the seasonal picture of adult ticks is incomplete. This is not the case with the immature forms.

Plant community relationships. Larvae were not found in the Pinyon-Juniper and Atriplex-Kochia communities. They were most frequently encountered in Coleogyne. Nymphs were absent from Salsola and Atriplex-Kochia, but were most frequent in Grayia-Lycium. The adults were likewise most abundant in Grayia-Lycium. No adults were taken in the Pinyon-Juniper and Salsola communities.

Comments. Although the type specimens from which Neumann (1901) described the species were "taken on a man and in a chicken house" in California, practically all adult specimens collected since that time have been found on the black-tailed jack rabbit.

All stages of development are known to occur in the temperate deserts of the western United States where rodents of several species serve as hosts for the immature stages, kangaroo rats being the principal hosts. The host-parasite association at the test site follows somewhat the same pattern as found in other parts of the desert areas of western United States.

From the data at hand it appears that there is only one generation a year, with eggs laid from July through September and hatching beginning as early as August. In studying the life history of this species, Allred and Roscoe (1956) found that the females oviposited within 20 days after detachment from a host. Incubation period of the eggs varied from 28 to 37 days, and the newly hatched larvae attached to hosts within nine days. Larval engorgement varied from 4 to 13 days and the larvae molted within 16 days. Nymphal engorgement and molting required up to 16 and 28 days, respectively. Our seasonal observations of these ticks at the test site are in agreement with Allred's and Roscoe's findings.

The pattern of distribution by stage and season agrees for the most part with the findings of Beck (1955), Gastfriend (1955) and Fremling and Gastfriend (1955) for similar studies conducted in Utah. Beck found the main seasonal peak for larvae to be in April and May, June for nymphs, and July for adults. Fremling and

Gastfriend observed brief larval peaks from September to October, in December, February, and March to May. Nymphs were highest in their study during May, June, and September and adults highest in July.

Fremling's and Gastfriend's observations were based on small samples from rabbits taken for only a one-year period. Inasmuch as rabbits are not the principal hosts for the immature stages of *D. parumapertus*, limited validity can be attributed to their study except for the adult stage of this tick. Beck's study was conducted for several years and involved rodent as well as rabbit hosts. Consequently, his study is assumed to be more representative of the cycle of *D. parumapertus* in Utah.

The major points of difference between the Nevada and Utah results were the spring peak in larval population which occurred earlier in Nevada than in Utah, the earlier nymphal population in Nevada, as well as the bimodal June and August peaks for adults which at the test site were earlier and later than the Utah studies.

Our observations agree in part with Beck, Fremling, and Gastfriend except for the slight differences in season as mentioned above. The February-March larval population likely was responsible for the May nymphs, which in turn were responsible for the August adults. These adults probably gave rise to the February-March larvae. However, other population peaks in Nevada possibly indicate a separate population of ticks which demonstrate different seasonal activity (Fig. 2). In this case the August larval population likely gave rise to the February nymphs, which in turn were responsible for the June adults, and so on to the August larvae.

There is little doubt that these ticks are influenced in their ecological distribution by the nature of the physical environment when off their hosts. The ticks at the test site were found most frequently where the plant cover and humus were more abundant than elsewhere and likely furnished a better chance of survival for the ticks by providing protection from high temperatures and low humidities. In the Salsola and Atriplex-Kochia communities where plant cover and humus are minimal, few ticks are apt to survive exposure to the elements when off their hosts. Consequently, few ticks of this species were found in these communities even though the common hosts of their immature stages occurred there in abundance. Such small numbers as were found in the Pinyon-Juniper community probably were due to the lower temperature extremes. Similar situations are known to occur farther north in the Great Basin where *D. parumapertus* occupies only the lower elevations of the valleys and foothills.

More intensive studies on all stages of development of this tick must be done before the entire life cycle can be considered as well known. This is especially true for the adults and their hosts. More data are needed with reference to the emergence of the various developmental stages as they are affected by environmental factors such as temperature and humidity.

Haemaphysalis leporis-palustris (Packard)

Hosts. Only four larvae were collected. They were taken from a chisel-toothed kangaroo rat and the desert cottontail. Ninety-five nymphs were taken from a southern pocket gopher, six Lincoln's sparrows, and desert cottontails. No adults were found.

Seasonal incidence. The larva on the rabbit was found in November, whereas those on the kangaroo rat were taken in February. The nymph on the bird was taken in May; all other nymphs were found in November.

Plant community relationships. The larvae were taken from the Grayia-Lycium and Mixed plant communities. The nymphs were found predominantly in Mixed, with small numbers found in Grayia-Lycium and Pinyon-Juniper.

Comments. This tick commonly occurs on rabbits and less frequently on rodents and birds. It is surprising that adults of this tick have not been found on black-tailed jack rabbits for many rabbits were examined. It is also unusual that only a few specimens of the immature stages have been collected from the hundreds of small rodents that were examined in this study.

There likely are two reasons for the scarcity in numbers of specimens of all stages of development having been taken at the test site. The collections of cottontail rabbits have been few in number. In addition, these cottontails are somewhat limited in their distribution at the site. They were encountered principally where some water was available as springs or seeps. A year-round study of cottontails at the few springs and seeps would no doubt provide a much different record than at present. On December 21, 1950, Beck collected 60 nymphs and 121 adults from a cottontail at Beaver Dam Wash, Utah, in an ecological situation somewhat similar to that at the Nevada Test Site.

Although it has been the rule rather than the exception for cottontail rabbits to be the main

hosts for this species of tick, a thorough survey of the ectoparasites of birds likely would produce additional specimens of this species.

Ixodes angustus Neumann

Hosts. No larvae of this species were taken. Thirty-six nymphs were found on eight rodents of four species. Three adults were taken from an antelope squirrel and two chisel-toothed kangaroo rats.

Seasonal incidence. Nymphs were found from April through June and in September and November. Adults were found from November through January.

Plant community relationships. Nymphs were found most commonly in the Mixed community but were also taken in Atriplex-Kochia and Pinyon-Juniper.

Comments. Cooley and Kohls (1945) listed 16 genera of animals which serve as hosts for *I. angustus* in northwestern United States. Gregson (1956) listed 13 genera as hosts from his studies in Canada. Allred, *et al.* (1960) listed six species from four genera of hosts for this tick in Utah, with larvae being taken only from *Peromyscus maniculatus*. The tick has an extensive geographic range in North America, extending from Alaska to southern California and to the eastern part of the United States.

The information from the literature indicates that this species is more abundant and has a wider range of distribution in nondesert situations. All the collections in Utah have been taken at high elevations in mountainous areas or in the northern part of the state. Gregson mentions the species extending across Canada, from Alaska to California, and "east to New York State." An examination of the host listing by Cooley and Kohls also shows host animals whose ecological distribution is either at higher altitudes in mountain ranges, foothills, the Pacific coastal region, or in the northern part of the United States. It appears that a principal factor directly affecting distribution is humidity.

On the above basis, the Mojave area would not be considered a region which would be productive of hosts on which this tick is normally found, and hence one would expect the tick to be limited in numbers collected as well as range of distribution at the test site. Such was the case!

The seasonal occurrence of this species at the test site is in agreement with findings of other workers.

Ixodes kingi Bishopp

Hosts. This tick was taken from 48 animals including two carnivores, a rabbit, and eight species of rodents. A total of 82 larvae was collected from the rabbit and from 45 rodents of seven species. The greatest number was taken from wood rats, with none found on carnivores or antelope squirrels. Thirty-two nymphs were taken from all the host species on which larvae were found except the coyote and the leporids. They were most abundant on the wood rat and chisel-toothed kangaroo rat. Only two adults were taken: a male from a coyote and a female from the chisel-toothed kangaroo rat.

Seasonal incidence. Larvae were found from March through December except in August and September. They were taken most frequently in April, although greatest numbers were found in October. From October through December they were found on a rabbit and wood rats, whereas from March through July they occurred on rodents of other species. Nymphs were found in December and January and from April through September except in July. They were taken most frequently from April through June. During the winter months they were taken principally from wood rats, whereas in summer they were found on other rodents. The male from a coyote was taken in November, and the female from a kangaroo rat in June.

Plant community relationships. Larvae were taken most frequently in the Grayia-Lycium and Coleogyne communities. Nymphs were found most frequently in Grayia-Lycium and Mixed. The adults were found in Grayia-Lycium and Atriplex-Kochia.

Comments. Cooley and Kohls (1945) and Allred *et al.* (1960) listed many species of hosts for this tick. Although the deer mouse and kangaroo rat are preferred hosts in Utah (Allred *et al.*, 1960), wood rats apparently are a common host at the test site. Except for their occurrence on wood rats in October, they were seldom found on a host in numbers of more than one or two. This is in agreement with Allred *et al.* who stated that few animals are heavily infested with this tick and most had only one or two.

Their seasonal occurrence is similar to that found by Cooley, Kohls, Allred *et al.* Figure 3 shows the population fluctuations of *I. kingi* larvae and nymphs. Adults were taken in insufficient numbers for inclusion. These data are indicative of possibly two generations a year. This assumption is based on the relative populations

of larvae and nymphs for each season. It is unlikely that a given larval population could give rise to a larger nymphal population. Consequently the larval peak in April likely gave rise to the nymphs in June and the larvae in October to the nymphs in December. Adults, which were not collected in any number at the test site, likely attain highest numbers on their hosts (unknown to us) about August and February.

It is interesting to note that although the nymphs were frequently found in the Mixed community, larvae were not so frequently found there. The relative frequency of occurrence of larvae and nymphs in other communities where they were found was about equal.

Ixodes oehotonae Gregson

Hosts. Seven larvae were taken from five antelope squirrels and a cliff chipmunk.

Seasonal incidence. Larvae were taken from January through June except in March.

Plant community relationships. Collections were made in Grayia-Lycium, Larrea-Franseria, Coleogyne, and Pinyon-Juniper communities. They were taken most frequently in Grayia-Lycium.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed nine species of six genera of mammals which serve as hosts for this tick. Our data from the test site for collections from antelope squirrels and the cliff chipmunk apparently are new host records.

The seasonal occurrence of the larvae at the test site is earlier than found by Cooley and Kohls, Allred *et al.* This is expected inasmuch as collections reported by them were made at higher elevations at more northerly latitudes.

Most published records of this tick are from hosts taken in forested mountain areas. Inasmuch as Allred *et al.* stated that in Utah it was found about equally in coniferous forest and desert shrub areas, its occurrence at the test site is not unusual.

Gregson (1956) cited this tick as the "pika tick," but most of the records for collections in Utah as reported by Allred *et al.*, and those taken at the test site indicate this species to have a wide selection of hosts.

Ixodes pacificus Cooley and Kohls

Hosts. Twelve larvae and a nymph were taken from four pocket mice.

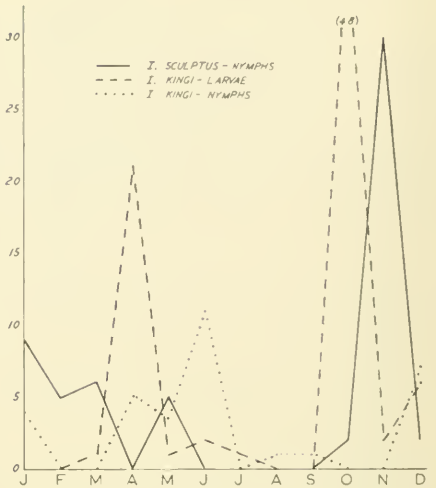

Fig. 3. Seasonal incidence of *Ixodes sculptus* and *I. kingi.*

Seasonal incidence. The larvae were taken in April and the nymph in October.

Plant community relationships. All the larvae were found in the Coleogyne community, whereas the nymph was taken in a Mixed community.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed a variety of hosts for this tick including lizards, domestic animals, and man. Records include pocket mice from California, but our records for other species of pocket mice at the test site apparently are new.

The seasonal incidence agrees with that stated by Cooley and Kohls.

Ixodes sculptus Neumann

Hosts. Two larvae, 58 nymphs, and two females were taken from 22 antelope squirrels. One nymph was taken from a Merriam's kangaroo rat. The antelope squirrel apparently is the preferred host of the nymphs.

Seasonal incidence. The larvae were found during the winter, nymphs in winter and spring, and the adults in the spring. No ticks of any stage of development were collected during the summer months.

Plant community relationships. The larvae were found only in the Coleogyne community.

The nymphs were found principally in the Coleogyne and Grayia-Lycium but also in the Mixed and Larrea-Franseria communities. The adults were taken in Coleogyne.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed squirrels of several species as the preferred hosts of this tick. Collection data for ticks found on the antelope squirrel and kangaroo rat at the test site apparently are new host records.

Our winter records for the larvae are later than those listed by Cooley and Kohls, Allred *et al.*

Although collections of larvae and adults of *I. sculptus* at the test site essentially are lacking, the data on nymphs are suggestive of more than one generation of ticks per year or more than one separate population (Fig. 3).

Ixodes spinipalpis Hadwen and Nuttall

Hosts. One nymph was taken from a kangaroo rat and seven nymphs from three pocket mice of two species.

Seasonal incidence. Nymphs were taken in February, April, June, and November.

Plant community relationships. The two communities represented by our collections were Larrea-Franseria and Mixed. Ticks were taken most frequently from the latter.

Comments. Cooley and Kohls (1945), Gregson (1956), and Allred *et al.* (1960) listed records of this tick from birds, rabbits, and rodents including pocket mice and kangaroo rats. Our records from the chisel-toothed kangaroo rat and little pocket mouse apparently are new. Seasonal findings are in agreement with other workers.

DISCUSSION

Of the 24 species of animals found infested with ticks, 17 were infested with larvae, 19 with nymphs, and only six with adults. Rodents of only two species were found to harbor adults. The paucity of adult ticks of some species taken may be explained on the basis of their known host and ecological relationships.

Antelope squirrels, chisel-toothed and Merriam's kangaroo rats were hosts for ticks of more species than were other animals. *Dermacentor parumapertus* apparently is the most widespread species at the Nevada Test Site. This is true with respect to both host and ecological distribution, although *Ixodes kingi* is almost as widespread. According to recent studies of this latter species by Gregson and Kohls, Gregson (correspondence) states that ticks of *I. kingi* in the Great Basin area are not typical of the *kingi* found east of the Rocky Mountains and may prove to be a different species.

Adults of *Argas persicus* are principally parasites of birds. The relatively small number of birds examined and the limited seasonal observation for their parasites at the test site would account in part for the low number of collections of this species. The mule deer, if examined on a year-round basis in a systematic manner, likely would produce a great number of *Dermacentor albipictus*. Adults of *Haemaphysalis leporis-palustris* occur most commonly on cottontail rabbits not only at the test site but elsewhere. Only a few of these hosts were taken at the test site mainly because of the limited areas in which they occur and lack of a systematic year-round collection.

With reference to *Ixodes angustus, I. ochotonae, I. pacificus, I. spinipalpis,* and *I. sculptus,* host records reported in the literature indicate that they occur on animals which commonly live in the Desert Woodland, at higher elevations, or in mountain forest areas. Migrations of animals such as domestic stock, deer, and carnivores across the lower valleys of the test site may account for the maintenance and occurrence of the immature stages of these species on rodents at the site. Beck (1955) reports several collections of *I. pacificus* taken from the mule deer in Utah. Most literature reports list the adults from larger animals such as deer, dogs, and man. Adults of some *Ixodes* such as *I. kingi* may infest carnivores. Badgers, bobcats, foxes, and coyotes occur commonly at the test site, but relatively few were examined for ectoparasites. As expected with *Dermacentor parumapertus* and *Otobius lagophilus,* their adults and nymphs, respectively, were commonly taken from jack rabbits which occur in abundance at the test site.

Our results are indicative that the nature of the habitat is influential on survival of the ticks when not on a host. Ticks were collected most frequently in the Grayia-Lycium, Mixed, and

Coleogyne communities (Table 2). The greatest number of species was also found in these communities. Although almost as many species were taken in the Larrea-Franseria community, their frequency of occurrence was only one-third to one-half that of the three communities above. Frequency of collections and fewest species of ticks occurred in the Salsola. These relationships likely are correlated with the amount of plant cover and humus under the plants which may provide microhabitats favorable for survival of ticks when not on their hosts.

Table 2. Frequency of tick collections by plant community.

Plant Community	No. tick species	Percent frequency of total collections*
Atriplex-Kochia	3	4.8
Coleogyne	6	24.4
Grayia-Lycium	7	33.6
Larrea-Franseria	5	10.3
Mixed	7	22.9
Pinyon-Juniper	3	3.0
Salsola	1	1.0

*Slightly skewed because of differences in collecting attempts.

The unusual number of species of ticks which occur in the comparatively small area of the Nevada Test Site may be explained in part on the nature of its geographical and ecological location. Relatively high mountain ranges and intervening valleys extend southward from the Great Basin region and merge into the Mojave region. In such a place of zoogeographic merging one may expect the unusual. For example, six species of *Ixodes* have been taken from the test site whereas less than a dozen are known for the whole state of Utah. A total of eleven kinds of ticks are known from the test site and only 17 are known for all of Utah.

Other species of ticks and new host associations for species already known most likely will be discovered at the test site, especially if emphasis is placed on the examination of birds, carnivores and other less frequently collected animals as well as their nests and burrows. Systematic surveys at higher elevations would likewise produce additional species.

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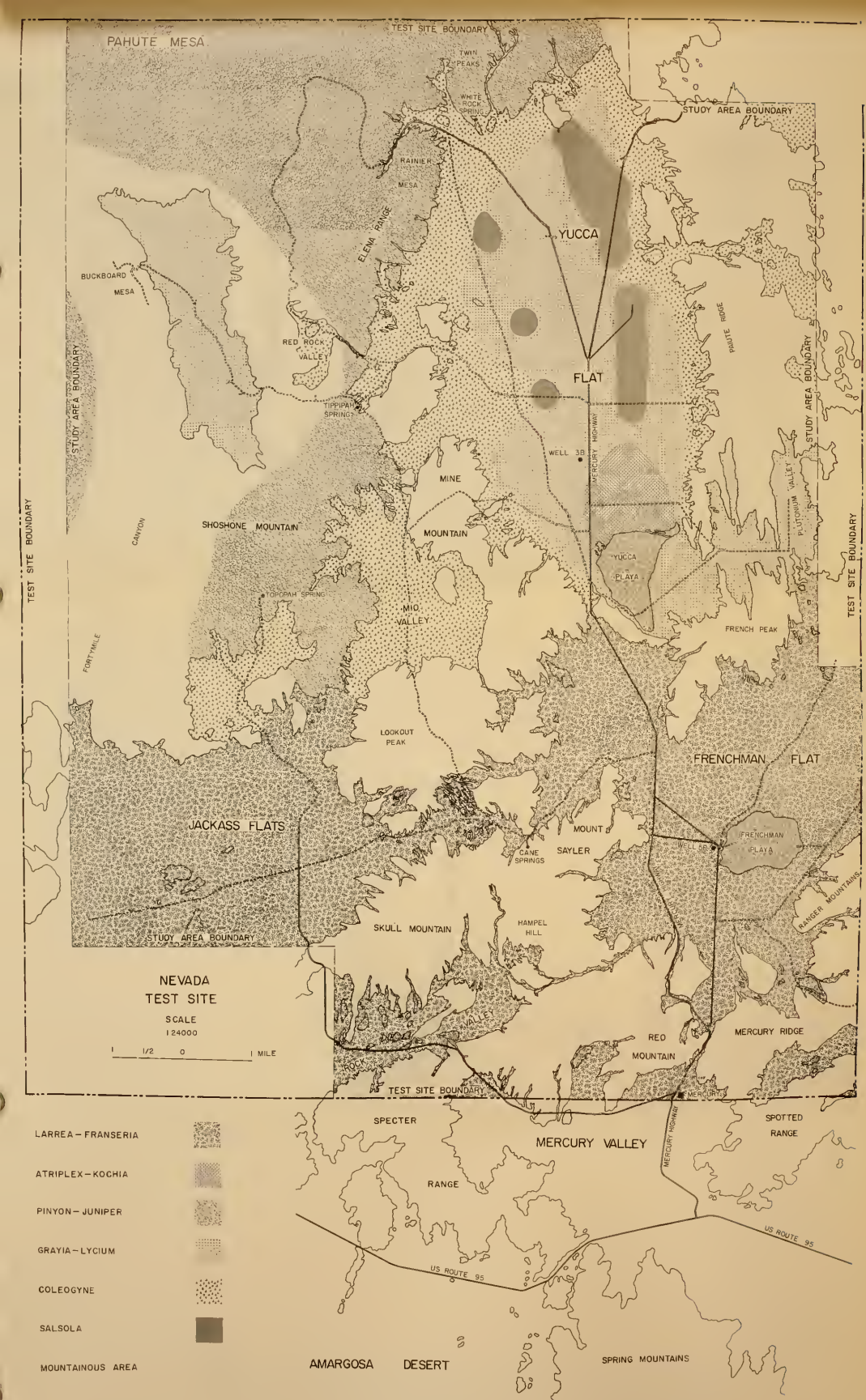

Fig. 4. Extent of the major plant communities — Nevada Test Site.

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ANNOTATED CHECKLIST OF THE PLANTS OF MESA VERDE, COLORADO

by

Stanley L. Welsh and James A. Erdman

Biological Series — Vol. IV, No. 2

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Errata sheet for Mesa Verde Plant List

p. 6: 2nd column, species 10, line 3; *argenta read argentea*

p. 7: 2nd column, species 5, WGRS 2274, Host Lupinus sp. read WGRS 2276 *Amelanchier-utahensis*

p. 7: 2nd column, species 14; WE 2534 read WE 2524

p. 10: 2nd column, *Berberideacae* read *Berberidaceae*

p. 10: 2nd column, species 5; *Ascelepias* read *Asclepias*

p. 11: 1st column, species 3; *Crythantha* read *Cryptantha*

p. 13: 1st column, species 5; *Agoseris aurantiaica* read *Agroseris aurantiaca*

p. 14: 1st column, species 4; *brachyphlla* read *brachyphylla*

p. 14: 2nd column, species 1; Drawf rabbit brush read Dwarf rabbit brush

p. 16: 2nd column, species 8; *Verbena* read *Verbesina*

p. 17: 1st column, species 4; *Arbis* read *Arabis*

p. 21: 1st column, species 7; *distant* read *distans*

p. 21: 2nd column, species 4; *Ellisia nycetela* read *Ellisia nyctelea*

p. 23: 2nd column, species 5; *Medicaga* read *Medicago*

p. 24: 2nd column, species 3; *Mentbelia* read *Mentzelia*

p. 25: 2nd column, species 2; *giganteus* read *gigantea*

p. 27: 1st column, species 2; *hirstissima* read *hirsutissima*

p. 28: 1st column, species 1; Sn 171 read SN 1713

p. 28: 2nd column, species 7; *Commandra* read *Comandra*

p. 30 2nd column, species 6; *Cympterus* read *Cymopterus*

p. 30: 1st column, species 5; *thapus* read *thapsus*

FOREWORD

The extended scientific program of the Wetherill Mesa Archaeological Project is developing many bodies of information, well worthy of publication, which do not lie in the mainstream of its own effort. This checklist of the plants of Mesa Verde, Colorado, is one of them. Dr. Welsh, associate professor of botany at Brigham Young University, has worked with the project since 1961 as its botanical taxonomist. During this period he has identified many thousands of plant fragments from our excavations. Mr. Erdman, the project's plant ecologist, has been with us since 1959 doing several ecological studies and carrying the responsibility for an environmental measurement program. He is a graduate student working toward the doctorate at the University of Colorado. Both men needed to know the flora of Mesa Verde National Park and indeed of the whole Mesa Verde area in order to carry on their research. Their field and laboratory work resulted in this valuable contribution.

The Wetherill Mesa Project is a part of the research program of the National Park Service locally financed in part by the National Geographic Society, to which we are indebted for a major share of the support for this study.

Douglas Osborne, Supervisory Archaeologist
Wetherill Mesa Archaeological Project

Contribution No. 4 of the Wetherill Mesa Archaeological Project, and Contribution No. 40 of the Brigham Young University Herbarium.

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CHECKLIST OF PLANTS OF MESA VERDE, COLORADO

INTRODUCTION

Mesa Verde is part of the pinyon-juniper climax region that extends through parts of Colorado, Utah, Arizona, New Mexico, Nevada, and California, and into northern Mexico. Situated in the southwestern corner of Colorado, its 200 square miles encompass the 80-square-mile Mesa Verde National Park, widely known for its prehistoric Indian cliff dwellings.

The plateau rises nearly 2,000 feet from the surrounding valleys to its highest elevation at the North Rim, 8,575 feet, and slopes gently southward to about 6,500 feet at the southern end, where the Mancos River cuts it off from Johnson Mesa, some 4 miles short of the New Mexico state line.

The 18-mile-long plateau is laced throughout with numerous parallel canyons, which generally run north-south. Thus Mesa Verde has many narrow, peninsular-like mesas rather than the one large "green table" that its name would suggest.

As might be expected the variations of slope, altitude, and soils support a vegetative cover that is far from uniform. While dominated by the pinyon pine and Utah juniper, Mesa Verde harbors small stands of Douglas-fir along the higher, north-facing slopes of the North Rim and in some of the more moist and protected canyon sites. A shrub zone of Gambel oak and Utah serviceberry is found along the upper reaches of the plateau. Sagebrush grows on the sandy loam terraces along the canyon floors, and also on some of the deep soils in burned-over areas and on prehistoric Indian sites.

The concern of the early Indian for his immediate plant environment was one of necessity —there was no turning to other markets. He derived sustenance directly from it; material for his dwellings and clothing; and even a measure of solace when he likely smoked a common weed, the wild tobacco.

In the archaeological work done on Wetherill Mesa (part of the Mesa Verde National Park) from 1959 through 1963, more than 80 species were recovered from the prehistoric ruins. (The most common of those recovered are indicated in the checklist by an asterisk.)

If the Indians of Mesa Verde have been vitally interested in the vegetation, so have the botanists. The area was visited by T. S. Brandegee in 1876 with the Hayden Survey. Hazel Schmoll and Deric Nusbaum (1925) have contributed to the understanding of the flora in the area, as have E. H. Bader (1928 and 1929), Mesa Verde Explorers Camp for Boys (1944), W. A. Weber (1949), and J. A. Erdman (1962).

We have based our work on the collections of other authors, as well as on our own. This paper is an attempt to bring all the previous lists up to date. A few species have been removed; many others have been added.

Our use of nomenclature is as current as possible, and we have used several sources to check the terminology (see list of references).

In general, identifications are by the authors, though many of Erdman's collections were determined by W. A. Weber of the University of Colorado. Gerald Ownbey, University of Minnesota, identified critical thistle specimens. Specimens of *Astragalus missouriensis* and *A. deterior* were verified by Rupert Barneby, New York Botanical Garden. *Quercus ajoensis* was determined by J M. Tucker, University of California. Fungi were identified by K. H. McKnight, Brigham Young University, and W. G. Solheim, University of Wyoming. Besides the specimens attributed to him, Weber verified critical materials from the Mesa Verde Park herbarium.

Collectors of a few specimens in the checklist are indicated with full names. More frequent contributors are keyed to the list of abbreviations below.

EHB	E. H. Bader
JAE	J. A. Erdman
MVEC	Mesa Verde Explorers Camp
N	D. Nusbaum
PRF	P. R. Franke
S	H. Schmoll
SLW	S. L. Welsh
SN	H. Schmoll and D. Nusbaum
WAW	W. A. Weber
WE	S. L. Welsh and J. A. Erdman
WEM	S. L. Welsh, J. A. Erdman, and G. Moore
WGRS	W. G. and R. Solheim
WW	S. L. and S. L. Welsh

The collections of Bader, Franke, Mesa Verde Explorers Camp, Nusbaum, Schmoll, and Solheim are in the herbarium of the Mesa Verde Park; Erdman's and Weber's are in the herbaria of the University of Colorado Museum; specimens collected by Welsh, et al., are in the Brigham Young University herbarium.

We wish to express our appreciation to Dr. Douglas Osborne, supervisory archaeologist of the Wetherill Mesa Archaeological Project, for his support and encouragement. Our thanks also go to Chester A. Thomas, Mesa Verde Park superintendent, and Mrs. Jean Pinkley, the park's chief archaeologist, for their cooperation.

ANNOTATED CHECKLIST

NONVASCULAR CRYPTOGAMS

Fungi, Lichens and Mosses

This section of the checklist concerns plants which have not been investigated thoroughly and must be considered tentative.

FUNGI

Agrocybe dura (Bolt. ex Fr.) Sing. Mushroom
Wetherill Mesa, Bobcat Canyon, WE 2557. Oak thicket under ponderosa pines. Late summer.

Armillaria alboanaripes Atkinson
Bobcat Canyon, WE 2547. Oak thicket under ponderosa pines. Late summer.

Astraeus hygrometricus (Pers.) Morgan Star puffball
Wetherill Mesa, Rock Springs, JAE F-11811. A star puffball with a reticulated endoperidium, occurring on dry slopes. Occasional throughout the pinyon-juniper forest.

Boletus brevipes (Peck) O. Kuntze
Bobcat Canyon, WE 2551. Oak thicket under ponderosa pines. Late summer.

Calvatia sp. Puffball
Navajo Canyon, North Rim, SLW 1757. A large puffball in excess of five inches in diameter. Summer

Clitocybe sp. Mushroom
Little Moccasin Mesa, WE 2536. Pinyon-juniper forest. Late summer.

Clitocybe sp.
Bobcat Canyon, WE 2553. Oak thicket under ponderosa pines. Late summer.

Clitocybe sp.
Bobcat Canyon, WE 2554. Oak thicket under ponderosa pines. Late summer.

Coprinus comatus (Fr.) S. F. Gray Shaggy mane inky cap
Wetherill Project Laboratory, JAE s.n. Pinyon-juniper forest. Late summer.

Coprinus micaceus Fr.
Moccasin Mesa, JAE s.n. Oak thicket. Late summer.

Cortinarius sp.
Little Moccasin Mesa, WE 2537. Pinyon-juniper forest. Late summer.

Crepidotus herbarum Peck Bracket fungus
Bobcat Canyon, WE 2561. Oak thicket under ponderosa pines. Late summer.

Crucibulum levis (DC.) Kambly & Lee Bird's nest fungus
Bobcat Canyon, WE 2566. Small drainage in Pinyon-juniper forest. Late summer.

Cyathis striatus Pers.
Bobcat Canyon, WE 2562. Small drainage in pinyon-juniper forest. Late summer.

Disciseda subterranea (Peck) Coker & Couch
Bobcat Canyon, WE 2566a. Small drainage in pinyon-juniper forest. Late summer.

Erysiphe cichoraccarum DC. Powdery mildew
Chapin Mesa, main campground WGRS 2291. Host, *Gutierrezia sarothrae.*

Fabraea maculata (Lev.) Atkinson
Chapin Mesa, Far View Group, WGRS 2282. Host, *Amelanchier utahensis.*

Fomes ellisianus Anderson Bracket fungus
Mancos Canyon, WEM 2166a. Host, *Shepherdia argenta.*

Fuligo intermedia Macbr. Slime mold
Chapin Mesa, Headquarters, WE 2444. Duff in pinyon-juniper forest. Late summer.

Fuligo megaspora Sturgis
Chapin Mesa, Headquarters, WE 2445. Duff in pinyon-juniper forest. Late summer.

Geastrum fenestriatum (Pers.) Fich. Star puffball
Bobcat Canyon, WE 2558a. Duff in pinyon-juniper forest. Late summer.

Geastrum mammosus Fr.
Wetherill Mesa, Long House, JAE F-11812. The common star puffball in the pinyon-juniper forest.

Geastrum sp. (near *G. arenarius* Lloyd)
Bobcat Canyon, WE 2558b. Duff in pinyon-juniper forest. Late summer.

Gymnosporangium speciosum Peck
Spruce Tree Canyon, WGRS 2267. Host, *Fendlera rupicola.*

Hadotrichum lupini Ell. & Ev.
Far View Group, WGRS 2274. Host, *Lupinus* sp.

Hygrophorus albiflavus Hesler & Smith Mushroom
Little Moccasin Mesa, WE 2535. Pinyon-juniper forest. Late summer.

Hygrophorus conicus (Fr.) Fr.
Bobcat Canyon, WE 2550. Oak thicket under ponderosa pines. Late summer.

Hygrophorus sp.
Bobcat Canyon, WE 2548. Oak thicket under ponderosa pines. Late summer.

Inocybe fastigiata Bres.
Bobcat Canyon, WE 2549. Oak thicket under ponderosa pines. Late summer.

Inocybe umbrina Bres.?
Little Moccasin Mesa, WE 2538. Pinyon-juniper forest. Late summer.

Inocybe sp.
Little Moccasin Mesa, WE 2538. Pinyon-juniper forest. Late summer.

Lactarius deliciosus (Fr.) S. F. Gray
Chapin Mesa, Headquarters, WEM 2114. Pinyon-juniper forest. Summer.

Leocarpus fragilis Rost. Slime mold
Bobcat Canyon, WE 2564. Attached to ponderosa pine cone, needles, and to an oak leaf. Oak thicket under ponderosa pines. Late summer.

Lepiota clypeolaria (Fr.) Quelet Mushroom
Little Moccasin Mesa, WE 2539. Pinyon-juniper forest. Late summer.

Lepiota sp.
Little Moccasin Mesa, WE 2540. Pinyon-juniper forest. Late summer.

Leucopaxillus albissimus (Peck) Singer.
Moccasin Mesa, JAE s. n. Oak thicket. Late summer

Lycoperdon umbrinum Pers. Puffball
Bobcat Canyon, WE 2559, 2560. Oak thicket under ponderosa pines. Late summer.

Microsphaera alni (Wallr.) Salm. Powdery mildew
Spruce Tree Canyon, WGRS 2263. Host, *Quercus gambelii.*

Phyllactinia corylea (Pers.) Karst.
Far View Group, WGRS 2274. Host. *Lupinus* sp.

Phyllosticta ferax Ell. & Ev.
Far View Group, WGRS 2274. Host. *Lupinus* sp.

Phyllosticta solidaginis Bresad.
Far View Group, WGRS 2286. Host, *Solidago petradoria.*

Polyporus cinnabarinus Jacq. ex Fr.
Little Moccasin Mesa, WE 2542. A red bracket fungus, attached to an oak twig. Pinyon-juniper forest. Late summer.

Polyporus volvatus Peck
Long House, SLW 1759; Headquarters, SLW 2509. A white bracket fungus, attached to a pinyon trunk. Throughout the Mesa Verde.

Puccinia aemulans Syd. Rust
Far View Group, WGRS 2281. Host, *Viguiera multiflora.*

Puccinia grindeliae Peck
Far View Group, WGRS 2285. Host, *Solidago petradoria.*

Puccinia rubig-vera (DC.) Wint.
Far View Group, WGRS 2279. Host, *Sitanion hystrix.*

Puccinia tumidipes Peck
Far View Group, WGRS 2272. Host, *Lycium pallidum.*

Russula sp. Mushroom
Little Moccasin Mesa, WE 2534. Pinyon-juniper forest. Late summer.

Russula sp.
Bobcat Canyon, WE 2552. Oak thicket under ponderosa pines. Late summer.

Sepultaria arenicola (Lev.) Massee Cup fungus
Moccasin Mesa, WE 2546. A small, pale gray cup-fungus; in soil beneath the pinyon-juniper forest. Late summer.

Tulostoma simulans Lloyd. Stalked puffball
Bobcat Canyon, WE 2567. Duff beneath the pinyon-juniper forest. Late summer.

Tulostoma sp.
Long House, JAE F-4872. The common stalked puffball in the pinyon-juniper forest.

Uromyces lupini Berk & Curt. Rust
Far View Group, WGRS 2292. Host, *Lupinus* sp.

Ustilago bromivora (Tul.) Fisch de Waldh. Smut
Chapin Mesa, Headquarters, WGRS 2276. Host, *Bromus tectorum.*

Volvariella speciosa (Fr. ex Fr.) Sing.
Little Moccasin Mesa, WE 2533. Pinyon-juniper forest. Late summer.

Xeromphalina sp. Mushroom
Bobcat Canyon, WE 2555. Oak thicket under ponderosa pines. Late summer.

LICHENS

Agrestia cyphellata J. W. Thomson
Wetherill Mesa, Mug House, JAE S-28245. Calcareous soils in the pinyon-juniper forest.

Caloplaca aurantiaca (Lightf.) Th. Fr.
Long House, JAE S-28266. On *Juniperus osteosperma.*

Candelariella vitellina (Ehrh.) Müll. Arg.
Long House, JAE S-28235.

Cladonia coniocraea (Floerke) Sandst.
Rock Canyon, Long House, JAE S-28228. A soil lichen in the pinyon-juniper forest.

Dermatocarpon lachneum (Ach.) A. L. Smith.
Long House, JAE S-28240. A component of the soil lichen crusts in the pinyon-juniper forest.

Dermatocarpon miniatum (L.) Mann.
Bobcat Canyon, JAE S-28238. Moist sandstone cliffs in side canyons.

Diploschistes scruposus (Schreb.) Norm.
Long House, JAE S-28246. Soil, in pinyon-juniper forest.

Glypholecia scabra (Pers.) Muell. Arg.
Bobcat Canyon, JAE S-28231. Moist, calcareous cliffs, in side canyons.

Lecidia decipiens (Ehrh.) Ach.
Long House, JAE S-28237. Soil, in pinyon-juniper forest.

Lecidea rubiformis Wahlb.
Long House, JAE S-28243. Soil; pinyon-juniper forest.

Leptogium hildenbrandii (Garov.) Nyl.
Bobcat Canyon, JAE S-28232. On *Quercus gambelii.*

Parmelia conspersa (Ehrh.) Ach.
Bobcat Canyon, JAE S-28229. A common foliose lichen growing primarily on rocks.

Parmelia olivacea (L.) Ach.
Long House, JAE S-28247. On *Pinus edulis*

Peltigera canina (L.) Willd.
Wetherill Mesa, ruin No. 16, JAE S-28244. Soil; pinyon-juniper forest.

Pertusaria sp.
Long House, JAE S-28074. On *Juniperus osteosperma.*

Physcia pulverulenta (Schreb.) Hampe
Long House, JAE S-28239. On *Juniperus osteosperma.*

Toninia candida (Web.) Th. Fr.
Bobcat Canyon, JAE S-28230. Calcareous sandstone.

Usnea hirta (L.) Wigg.
Rock Canyon, Long House, JAE S-28236. On *Pinus edulis* and *Juniperus osteosperma.*

Xanthoria polycarpa (Ehrh.) Rieb.
Long House, JAE S-28234. On *Philadelphus microphyllus.*

MOSSES

Amblystegium compactum (C. M.) Aust.
Bobcat Canyon, JAE B-3675. Soil in moist caves.

Bryum cuspidatum (Br. & Sch.) Schimp.
Bobcat Canyon, JAE B-3679. Under brush thickets.

Bryum turbinatum (Hedw.) Schwaegr.
Rock Canyon, ruin No. 12, JAE B-3676. Moist coal outcrops.

Bryum sp.
Long House, JAE B-6119. A sterile, common moss associated with the lichen crusts and pedestals of the pinyon-juniper forest.

Ceratodon purpureus (Hedw.) Brid.
Long Canyon, JAE B-3680. Under oak thickets.

Encalypta vulgaris Hedw.
Long House, JAE B-6122.

Grimmia anodon Br. & Sch.
Mug House, JAE B-6118. Sandstone rocks.

Grimmia apocarpa Hedw.
Bobcat Canyon, JAE B-3681. Bedrock.

Grimmia calyptrata Hook.
Rock Canyon, JAE B-3682. Talus slopes.

Gymnostomum calcareum Nees & Hornsch.
Rock Canyon, JAE B-3684. Calcareous sandstone seep walls.

Hypnum revolutum (Mitt.) Lindb.
Wetherill Mesa, east rim. JAE B-3685.

Leskea tectorum (A. Br.) Lindb.
Long House, JAE B-6124. On *Juniperus osteosperma.*

Orthotrichum alpestre Hornsch.
Long House, JAE B-6115. On *Juniperus osteoperma.*

Orthotrichum hallii Sull.
Bobcat Canyon, JAE B-3686. Shaded, moist ledges.

Orthotrichum jamesianum Sull.
Bobcat Canyon, JAE B-3687. Under calcareous ledges.

Timmia bavarica Hessl.
Bobcat Canyon, JAE B-3689. On shaded ledges.

Tortula obtusifolia Schleich.
Rock Canyon, JAE B-3691. Sandstone.

Tortula ruralis (Hedw.) Schwaegr.
Long House, JAE B-6120. An ubiquitous moss forming dense mats in the pinyon-juniper forest throughout the Mesa Verde.

Tortula subulata Hedw.
Rock Canyon, JAE B-3694. Calcareous stream-bed below an extensive spring.

Weisia controversa Hedw.
Long House, JAE B-3695. On decaying *Juniperus osteosperma.*

VASCULAR CRYPTOGAMS

Equisetaceae — Horsetail Family

Equisetum laevigatum A. Br. Horsetail
Chapin Mesa, Headquarters, WEM 2108; Mancos Canyon, WEM 2162. Common only in areas of abundant moisture.

Equisetum prealtum Raf.
Mancos Canyon, Soda Canyon Tipoff, MVEC 25.

Polypodiaceae — Fern Family

Adiantum capillus-veneris L. Maidenhair fern
Chapin Mesa, Fewkes Canyon, EHB 222. Rare.

Cheilanthes feei Moore. Lip fern
Chapin Mesa, Spruce Tree House, SN 1766; Cliff Canyon, EHB 20; Rock Canyon, ruin No. 16, JAE 72. The most common of the ferns; found on ledges and in crevices of the more mesic side canyons.

Cystopteris fragilis (L.) Bernh. Brittle fern
Morfield Canyon, EHB. 204. Rare.

Woodsia oregana D. C. Eaton.
Rock Springs, MVEC 147; Moccasin Mesa, Pine Canyon, WEM 2133. Locally common in the more moist canyons.

PHANEROGAMS
Cone and Seed-bearing Plants

Gymnospermae
Conifers and Allies

Ephedraceae — Jointfir Family

°*Ephedra viridis* Coville Mormon tea
Chapin Mesa, Square Tower House, SN 1789; North Rim, MVEC 74; Chapin Mesa, Headquarters, WW 1540; Long House, JAE 14; Chapin Mesa, south rim, JAE 329. A shrub common in the southern part of the Mesa Verde and on the slopes of the canyons; pinyon-juniper forest.

Pinaceae — Pine Family

°*Juniperus osteosperma* (Torr.) Little Utah juniper
Chapin Mesa, Headquarters, S-1687; Chapin Mesa, Cedar Tree Tower, EHB 2; Spruce Tree Canyon, EHB 327; Far View Group, WW 1530; Rock Canyon, ruin No. 12, JAE 96. Common throughout the Mesa Verde, but more dominant in its southern part; a codominant in the pinyon-juniper forest.

Juniperus scopulorum Sarg. Rocky Mountain juniper
Cliff Canyon, EHB 22; Point Lookout, PRF 11; Spruce Tree Canyon, WW 1558; Wetherill Mesa Burn, planted, JAE 110. Common along the North Rim; occurs elsewhere in moist draws and canyons.

°*Pinus edulis* Engelm. Pinyon pine
Chapin Mesa, Headquarters, S 1571; Far View Group, WW 1531; Chapin Mesa, Headquarters, WAW 5244; Bobcat Canyon, JAE 77. The most abundant tree species in the Mesa Verde; a codominant of the pinyon-juniper forest.

°*Pinus ponderosa* Dougl. Ponderosa pine
North Rim, Knife Edge, MVEC 79; Bobcat Canyon, JAE 117, WE 1612. Rare; occurring as small relict stands throughout the Mesa Verde. The North Rim, at an elevation of 8000 feet, should possibly support a montane forest; this problem remains an enigma and certainly bears investigating.

°*Pseudotsuga menziesii* (Mirb.) Franko Douglas fir
North Rim, EHB s. n. (without number); Bobcat Canyon, JAE 80; Spruce Canyon, JAE 283; Spruce Tree Canyon, WW 1557. Common in mesic draws and side canyons, and on the Mesa top along the North Rim. This is the "spruce" of Spruce Tree House, Spruce Tree Canyon, and Spruce Canyon.

ANGIOSPERMAE
Flowering Plants

ACERACEAE — Maple Family

Acer glabrum Torr. Rocky Mountain maple
Prater Canyon, SN 1721; Wetherill Mesa, North Rim, JAE 112; North Rim, B Cut, JAE 365, WEM 2140. A shrub common only below the North Rim escarpment. Spring.

Acer grandidentatum Nutt. ex T. & G. Big-toothed maple
North Rim, B Cut, WAW 5233. This site below the escarpment is the only place in Colorado where big-toothed maple has been found (Weber, 1950); the species is abundant in adjacent Utah. Spring.

°*Acer negundo* L. Boxelder
Prater Canyon, SN 1711, MVEC 101; Soda Canyon Tipoff, MVEC 30. Somewhat rare; occurring throughout the Mesa Verde only in shaded, moist sites. Spring.

AMARANTHACEAE — Amaranth Family

Amaranthus graecizans L. Pigweed
Chapin Mesa, Headquarters, WAW 5237; Wetherill Project Laboratory, JAE 229. Adventive in disturbed sites; occasional. Summer.

Amaranthus hybridus L.
Far View Group, SLW 1853. Adventive in disturbed sites; occasional. Summer.

ANACARDIACEAE — Sumac Family

°*Rhus trilobata* Nutt. Skunkbush
Spruce Tree Canyon, SN 1782; Soda Canyon Tipoff, MVEC 26; Rock Canyon, ruin No. 12, JAE 99; Spruce Tree Canyon, WW 1556. Common in side canyons and drainages. This shrub flowers in early spring before leaves appear.

°*Toxicodendron radicans* (L.) Kuntze Poison ivy
Spruce Tree Canyon, WAW 5238; Moccasin Mesa, Pine Canyon, WEM 2120. Occurs at base of cliffs and on ledges of moist side canyons. Spring.

APOCYNACEAE — Dogbane Family

Apocynum cannabinum L. Dogbane
Pine Canyon, WEM 2119. Rare; this specimen was taken in a stand of aspen in a moist, shaded box canyon. Spring.

ASCLEPIADACEAE — Milkweed Family

Asclepias capricornu Woodson Milkweed
Wickiup Canyon, SN 1636; Long House, JAE 153; Chapin Mesa, Headquarters, WEM 2081. Occurs occasionally throughout the pinyon-juniper forest. Summer.

Asclepias speciosa Torr.
Morfield Canyon, EHB 203. Probably adventive; apparently rare. Summer.

Asclepias subverticillata (A. Gray) Vail
Chapin Mesa, Navajo Hill MVEC 260; Chapin Mesa, Headquarters, SLW 2213. Occasional in waste places; mesa top. Summer.

BERBERIDECEAE — Barberry Family

°*Berberis repens* Lindl. Oregon grape
Navajo Canyon, SN 1627; Prater Canyon, MVEC 81; Rock Canyon, ruin No. 16, JAE 71; Spruce Tree Canyon, JAE 281. Common in side canyons under shady thickets, forming a dense, evergreen ground cover. Spring.

BETULACEAE — Birch Family

Betula occidentalis Hook.
Rocky Mountain birch
Locality none, C. W. Quaintance s. n. (Mesa Verde herbarium). Apparently rare, the only known stand occurring in a shady site in Johnson Canyon south of the Mancos River.

Boraginaceae — Borage Family

Cryptantha bakeri Greene
Chapin Mesa, Headquarters, SN 1732; Soda Canyon Tipoff, MVEC 46; Soda Canyon, Battleship Rock, MVEC 107; Long House, JAE 39; Navajo Canyon, JAE 294. Common throughout the Pinyon-juniper forest. Spring.

Cryptantha fendleri (A. Gray) Greene
Morfield Canyon, EHB 288.

Crytantha flava (A. Nels.) Payson
Wetherill Mesa, south end, WEM 2184. Known only from the lower parts of the Mesa Verde. Spring.

Cryptantha gracilis Osterh.
Chapin Mesa, Headquarters, SN 1689; Chapin Mesa, south rim, JAE 269. Abundant under the forest at lower elevations. A spring annual.

°*Hackelia gracilenta* (Eastw.) Johnston
Spruce Canyon, SN 1660; Navajo Canyon, Ross s. n. (Mesa Verda herbarium); Rock Springs, MVEC 146; Bobcat Canyon, JAE 46. Common in shaded side canyons under thickets. Spring.

°*Lappula redowskii* (Hornem.) Greene var. *redowskii* Stickseed
Confluence of Navajo and Wickiup Canyons, SN 1650; Spruce Canyon EHB 11; Rock Springs, JAE 27; Jackson Butte, west rim, JAE 278; Chapin Mesa, Wetherill Project Laboratory, JAE 288, 291. Navajo Canyon, JAE 297. An abundant weedy annual found especially in disturbed sites. Spring.

Lappula redowskii var. *cupulata* (A. Gray) Jones
Prater Canyon, SN 1724. Spring.

Lithospermum incisum Lehm. Puccoon
Navajo Canyon, JAE 293; Chapin Mesa, south end, JAE 298. Occasional throughout the pinyon-juniper forest. Spring.

°*Lithospermum ruderale* Dougl.
North Rim, Switchbacks Road, SN 1759, EHB 64; Park Point, MVEC 70; Wetherill Mesa, North Rim, JAE 139, 151; Far View Group, JAE 304; Morfield Burn, JAE 357. Fairly common throughout the northern part of the Mesa Verde, in the brush zone. Spring.

Mertensia fusiformis Greene Bluebells
Park Point, SN 1585; Navajo Canyon, EHB 33; Wetherill Mesa, North Rim, JAE 202; Park Point, JAE 285; Prater Canyon, JAE 362. Common in the brush zone along the North Rim. Spring.

Cactaceae — Cactus Family

Echinocactus mesa-verdae (Boiss. & David.) Benson
Not collected. Endemic to the Jackson Butte area below the west rim of the Mesa Verde in the saltbush desert (Boissevain and Davidson, 1940). Early spring.

Echinocactus whipplei Engelm. & Bigel. Fishhook cactus
Not collected. Common along the south end of the Mesa Verde. Spring.

°*Echinocereus coccineus* Engelm. Hedgehog cactus
Confluence of Spruce and Navajo Canyons, SN 1655; Long House, JAE 43. Common along the rimrock areas of the Mesa Verde. Spring.

Echinocereus fendleri (Engelm.) Rumpler
Mancos Canyon, Soda Canyon Tipoff, MVEC 29. The specimen consists of a single flower and the diagnostic color is difficult to establish. It may represent a large-flowered form of the preceding species. However, Weber, (1955) has collected this species below Soda Canyon Tipoff, WAW 5449.

Mamillaria vivipara (Nutt.) Haw Ball cactus
Chapin Mesa, Headquarters, SN 1791. Occasional throughout the pinyon-juniper forest. Spring.

°*Opuntia davisii* Engelm. & Bigel. Rattail cactus
Navajo Canyon, SN 1767; Soda Canyon Tipoff, MVEC 28. Rare; occurring only in the canyons. Summer.

Opuntia hystricina Engelm. & Bigel. ? Prickly pear
Spruce Tree Canyon, WEM 2078. This specimen has the characteristics attributed to the species. However, the *Opuntia* species (especially *O. polyacantha* and this one) show considerable variation and intergradation. It is possible that *O. rhodantha* also occurs on the Mesa. Certain specimens resemble that taxon.

°*Opuntia phaeacantha* Engelm.
Spruce Canyon, SN 1731; Chapin Mesa, Pool Canyon, WEM 2181. Common on the mesa tops to the south and in the deeper canyons. Spring.

°*Opuntia polyacantha* Haw
Wickiup Canyon, SN 1642; Morfield Canyon, MVEC 100; Long House JAE 42, 73. Very common throughout the Mesa Verde pinyon-juniper forest. Spring.

CAPPARIDACEAE — Capper Family

Cleome lutea Hook. Yellow spiderflower
Confluence of Navajo and Spruce Canyons, SN 1739. *C. lutea* has not been noted in the Mesa Verde by the present authors. It is presumed to be rare. Summer.

°*Cleome serrulata* Pursh Beeplant
Morfield Canyon, EHB 289, 312; Rock Canyon, Long House, JAE 125. Rare in the Mesa Verde, growing in sandy, disturbed sites. Summer.

Cleome serrulata Pursh var. *angustum* (Jones) Tidestr.
Morfield Canyon, EHB 312. Summer.

CAPRIFOLIACEAE — Honeysuckle Family

°*Sambucus coerulea* Raf. Blue elderberry
The Knife-Edge, SN 1764. Apparently restricted to the North Rim escarpment. Summer.

°*Symphoricarpos oreophilus* A. Gray Snowberry
Navajo Canyon, SN 1599; Spruce Canyon, SN 1727; Morfield Canyon, MVEC 20; Navajo Hill, MVEC 59; Rock Canyon, JAE 86; Navajo Canyon, JAE 224; North Rim, B Cut, JAE 336; North Rim, WW 1524. Common under brush along the North Rim and in shaded side canyons. Spring.

CARYOPHYLLACEAE — Pink Family

Arenaria congesta Nutt. Sandwort
Prater Canyon, SN 1704; Navajo Hill, MVEC 63, 116; Park Point, MVEC 153; North Rim, B Cut, WEM 2143. Common in the brush zone along the North Rim. Spring.

Arenaria macrophylla Hook.
North Rim, B Cut, WEM 2146. In Douglas fir stands below the North Rim escarpment; occasional. Summer.

Silene antirrhina L. Campion
Pool Canyon, WEM 2176. Occasional. Spring.

Silene noctiflora L.
Chapin Mesa, residence area, JAE 390. A garden weed. Spring.

Stellaria jamesiana Torr. Chickweed
Prater Canyon, SN 1707; Park Point, EHB s.n.; Navajo Canyon, MVEC 109, 287; North Rim, WEM 2147. Occasional in oak and Douglas fir stands on the north rim. Early summer.

CELASTRACEAE — Staff Tree Family

°*Pachystima myrsinites* Raf. Mountain lover
Spruce Tree Canyon, SN 1661, EHB 8; Rock Springs, JAE 188; Spruce Tree House, WW 1555. Shady sites in the canyons; occasional. Spring.

CHENOPODIACEAE — Goosefoot Family

°*Atriplex canescens* (Pursh) Nutt. Fourwing saltbush
Far View Group, SN 1774; Navajo Canyon, SN 1773, EHB 242; Soda Canyon Tipoff, MVEC 33; Morfield Canyon, MVEC 98; Park Point, MVEC 163; Long House draw, JAE 56; Navajo Canyon, JAE 227; Far View Group, WW 1536. Widespread throughout the Mesa Verde from the lowest to the highest elevations; seldom abundant. Summer.

°*Atriplex confertifolia* (Torr. & Frem.) S. Wats. Shadscale
Spruce Canyon, SN 1735, JAE 346, WEM 2073. Uncommon; occurring on slopes in the canyons. Summer.

Atriplex corrugata S. Wats. Mat-atriplex
Jackson Butte, west rim, JAE 280. Desert west of the Mesa Verde; a dominant species on the Mancos shale formation. Spring.

Atriplex rosea L. Annual saltbush
Confluence of Navajo and Spruce Canyons, WAW 3623. Rare.

Chenopodium berlandieri Moq. Goosefoot
Morfield Canyon, PRF 12. Occasional. Summer.

Chenopodium fremontii S. Wats.
Chapin Mesa, Headquarters, WAW 5218; Far View Group, SLW 1856. Disturbed sites; locally abundant. Summer.

Chenopodium leptophyllum Nutt. ex S. Wats.
Park Point, WAW 5231. Oak thickets. Summer.

Chenopodium pratericola Rydb.
Morfield Burn, JAE 207; Wetherill Mesa, Badger House, JAE 237; Mug House, SLW 1849. A pioneer in recently disturbed sites. This was a codominant with sunflower the

first year after the Morfield fire, and is abundant on the backfill of recently excavated ruins.

Eurotia lanata (Pursh) Moq. Winterfat
Park entrance, PRF 1. Apparently not found on the Mesa Verde proper, but below it on the Mancos shale formation. Summer.

Salsola kali L. Russian thistle
Chapin Mesa, Headquarters, WAW 5236; Morfield Burn, JAE 239. An Old World adventive in disturbed sites; occasional. Summer.

°*Sarcobatus vermiculatus* (Hook.) Torr. Greasewood
Confluence of Navajo and Spruce Canyons, SN 1737; Navajo Canyon, JAE 226; Spruce Canyon, WEM 2070. Canyon bottoms and shale outcrops; locally common. Summer.

Compositae — Sunflower Family

Achillea millefolium L. Yarrow
Far View Group, SN 1757; Morfield Canyon, MVEC 93; Park Point, MVEC 158; Rock Canyon, JAE 66; Wetherill Mesa, North Rim, JAE 136. Common in the shrub zone along the North Rim. Summer.

Agoseris aurantiaica (Hook.) Greene Mountain dandelion
Morfield Canyon, EHB 97, 285. Spring.

Agoseris glauca (Pursh) D. Dietr.
Park Point, SN 1586. Spring.

Ambrosia coronopifolia T. & G. Ragweed
Chapin Mesa,Headquarters, SLW 2211. Rare; probably adventive. Summer.

Antennaria dimorpha (Nutt.) T. & G. Pussytoes
Bobcat Canyon, JAE 16; Prater Canyon, JAE 363. Exposed, sandy sites; occasional. Spring.

Antennaria parvifolia Nutt.
Wickiup Canyon, PRF 1786; Morfield Canyon, MVEC 12; Bobcat Canyon, JAE 21, 68; Navajo Canyon, SLW 1748; Chapin Mesa, Headquarters, WEM 2094. Common throughout the Mesa Verde. Summer.

Antennaria rosea (Eaton) Greene
Navajo Canyon, M. E. C. (surname unknown) s. n. Summer.

Artemisia dracunculus L. Tarragon
Chapin Mesa, Headquarters, D. Watson, s. n.; Wetherill Mesa, North Rim, JAE 127, SLW 1659. Common especially in the saddles and meadows along the North Rim. Autumn.

Artemisia frigida Willd. Fringed sagebrush
Morfield Canyon, EHB 314, PRF 16; Navajo Canyon, JAE 240. Uncommon; canyons and North Rim area. Autumn.

°*Artemisia ludoviciana* Nutt.
Switchbacks Road, EHB 293; Navajo Canyon, EHB s.n.; Rock Canyon, ruin No. 12, JAE 164; Spruce Tree Canyon, JAE 243; Long House, SLW 1651. Shaded side canyons and North Rim; common. Autumn.

Artemisia nova A. Nels. Black sagebrush
Square Tower House, EHB 326; Park Point, JAE 238. The dominant shrub in the openings between the thickets of oak and serviceberry along the North Rim; generally indicative of shallow soils. Autumn.

Artemisia spinescens D. C. Eaton Bud sagebrush
Jackson Butte, below west escarpment, JAE 279. Occurs in the desert below the Mesa Verde proper. Spring.

°*Artemisia tridentata* Nutt. Big sagebrush
Far View Group; SN 1686, EHB 307, WW 1535; Navajo Canyon, JAE 241. The dominant climax species of the canyon bottom floodplains on sandy alluvium; also the dominant in successional stands on the mesa top where the soil mantle is deep, and an excellent indicator of prehistoric sites. Autumn.

Aster arenosus Blake Aster
Prater Canyon, SN 1703; Chapin Mesa, the Glades, EHB 127; Soda Canyon Tipoff, MVEC 36; Spruce Canyon, JAE 345. Common on exposed, shale slopes; occasional elsewhere. Spring.

Aster bigelovii A. Gray
Chapin Mesa, Sun Temple, SN 1750; Morfield Canyon, EHB 301; Navajo Canyon, JAE 221; Badger House, JAE 236; Long House, SLW 1656; Mug House, SLW 1850. A pioneer on backfill and other disturbed sites; elsewhere occasional. Summer-autumn.

Aster falcatus Lindl. ex DC. White aster
Park entrance, PRF 3; North Rim, EHB 302. Common on the North Rim. Late summer and autumn.

Aster glaucoides Blake.
Point lookout, EHB 216. Locally abundant on shale, especially along the North Rim. Summer-autumn.

Bahia dissecta (A. Gray) Britt.
Spruce Tree Canyon, Museum, WAW 5214; Bobcat Canyon rim, WE 2568. Rare. Autumn.

Balsamorrhiza sagittata (Pursh) Nutt. Balsamroot
Little Soda Canyon, East Fork, SN 1574; Spruce Tree Canyon, WAW 5214; Wetherill Mesa, North Rim, JAE 134; Park Point, JAE 331. Common; openings of the shrub zone along the North Rim. Spring.

Brickellia brachyphlla A. Gray Brickellbush
Spruce Tree Canyon, Museum, WAW 5216. Autumn.

°*Brickellia californica* (T. & G.) A. Gray
Cliff Canyon, EHB 305; Spruce Tree Canyon, WAW 5215, JAE 242; Moccasin Mesa, south rim, JAE 246; Long House, SLW 1655. Common; base of cliffs and on ledges of side canyons. This is by far the most abundant of the brickellbushes in the Mesa Verde. Autumn.

Brickellia grandiflora (Hook.) Nutt.
Navajo Canyon, SN 1746. Occasional; North Rim. Autumn.

Brickellia oblongifolia (Nutt.) Kuntze
Wetherill Mesa, south end, WEM 2188. Known in the Mesa Verde only from the basalt plug at the south end of Wetherill Mesa. Summer.

Brickellia scabra (A. Gray) A. Nels.
Spruce Tree Canyon, WAW 5243, SLW 1858; Moccasin Mesa, Pine Canyon, JAE 247. Restricted to exposed, often shaley sites. Autumn.

Centaurea repens L. Russian knapweed
Chapin Mesa, Headquarters, SLW 2212. An Old World weed; rare. Summer.

Chaenactis douglasii (Hook.) H. & A. False yarrow
Confluence of Wickiup and Navajo Canyons, SN 1632; Cedar Tree Tower, MVEC 1; Prater Canyon, MVEC 85; head of Bobcat Canyon, JAE 20. Common along the mesa rims and in the canyons. Spring.

Chrysopsis villosa (Pursh.) Nutt. Golden aster
Switchbacks Road, SN 1755; Spruce Tree Canyon, EHB s.n.; Soda Canyon Tipoff, MVEC 35; Rock Springs, MVEC 129; Long House, JAE 13. Common along the mesa rims and cliffs. Summer.

Chrysothamnus depressus Nutt. Drawf rabbitbrush
North Rim, EHB 295; Wetherill Mesa, Bobcat drainage, JAE 178; Chapin Mesa, Headquarters, SLW 2570. Occasional; openings along the North Rim and in stands of big sagebrush and pinyon-juniper on the mesa tops. Summer.

°*Chrysothamnus nauseosus* (Pall.) Britt. Rabbitbrush
North Rim, EHB 303; Morfield Canyon, EHB 319; Rock Springs, MVEC 133; Wetherill Mesa, North Rim, JAE 126; Long Mesa, North Rim, JAE 232; Long House, SLW 1660. Common in the saddles along the North Rim; elsewhere, occurs in disturbed areas such as recent burns and road cuts. Autumn.

Chrysothamnus viscidiflorus (Hook.) Nutt.
Rock Canyon, JAE 106. Uncommon, occurring on the canyon bottom floodplains. Summer-autumn.

Cirsium arvense (L.) Scop. Canadian thistle
Chapin Mesa, Headquarters, SLW 2207. A noxious Old World weed. Summer.

Cirsium lanceolatum (L.) Hill Bull thistle
Chapin Mesa, Headquarters, SLW 2569. A noxious Old World weed. Summer-autumn.

Cirsium neomexicanum A. Gray ? Thistle
Spruce Canyon, SN 1729. This specimen may belong to *C. tracyi* (see below). Summer.

Cirsium pulchellum (Greene) W. & S.
Confluence of Long and Navajo Canyons, SN 1776; Rock Canyon, WE 1620. Occasional in canyon bottoms. Summer.

Cirsium tracyi (Rydb.) Petrak
Rock Canyon, WE 1618. Occasional; canyon bottoms. Summer.

Cirsium undulatum (Nutt.) Spreng.
North Rim, EHB 180; Wetherill Mesa, North Rim, JAE 140; Morfield Burn, JAE 387; Wetherill Mesa, North Rim, WEM 2203. Common in disturbed sites. Summer.

Conyza canadensis (L.) Cronq. Horseweed
Confluence of Navajo and Wickiup Canyons, PRF 1803; Mug House, JAE 391. Disturbed sites; the later collection was made from the backfill of a recently excavated ruin. Summer.

Crepis acuminata Nutt. Hawkbeard
Switchbacks Road, SN 1756, EHB 181b; Wetherill Mesa, North Rim, MVEC 124, WEM 2204; Park Point, MVEC 154; Navajo Hill, MVEC 286. Common in the brush zone along the North Rim. Summer.

Crepis intermedia A. Gray
Navajo Hill, MVEC 60; Wetherill Mesa, North Rim, JAE 131; Morfield Canyon, WEM 2063. Occasional; openings along the North Rim. Summer.

Crepis modocensis Greene
School Section Canyon, EHB 110. This specimen has not been examined by the authors. Another specimen collected by Bader in School Section Canyon belongs to another species. It was labeled as *C. modocensis*, however.

Crepis occidentalis Nutt.
School Section Canyon, EHB s. n.; Park Point, WEM 2087; Wetherill Mesa, North Rim, WEM 2202. Common in the brush zone along the North Rim. Summer.

Erigeron divergens T. & G.
Spreading fleabane
Navajo Canyon, S 1771; Wetherill Mesa, Bobcat drainage, JAE 17, 185; Rock Springs draw, JAE 392; Park Point, WEM 2084. Occasional along the North Rim and elsewhere. Summer.

Erigeron eatonii A. Gray
Prater Canyon, SN 1708.

Erigeron engelmannii A. Nels.
Park Point, EHB 160. This specimen may well belong to *E. pumilus* which is separated on technical characters.

Erigeron speciosus (Lindl.) DC. var. *macranthus* (Nutt.) Cronq. Morfield Canyon, EHB 264; Park Point, MVEC 157; Far View Group, MVEC 218; Rock Canyon, JAE 93. Common at edge of thickets along the North Rim. Summer.

Erigeron utahensis A. Gray
Long Canyon, PRF 1777; Wetherill Mesa, Double House, Ross 135. Occasional on talus slopes. Summer.

Eupatorium herbaceum (A. Gray) Greene
Moccasin Mesa, Pine Canyon, JAE 245. Canyon ledge. Summer.

Grindelia aphanactis Rydb. Gumweed
Chapin Mesa, Headquarters. WAW 5219. Summer.

Grindelia arizonica A. Gray
North Rim, PRF s. n. Common along the North Rim. Summer.

Gutierrezia sarothrae (Pursh) Britt. & Rusby.
Snakeweed
Square Tower House, PRF 1813; Wetherill Burn, Rock Springs, JAE 123; ruin No. 12, JAE 163; Navajo Canyon, JAE 223. Common in the canyons and lower parts of the Mesa Verde; occurs also in disturbed areas. Summer.

Haplopappus armerioides (Nutt.) A. Gray
Goldenweed
Soda Canyon, EHB s. n.; North Rim, MVEC 71; Wetherill Mesa, south end, JAE 214; Chapin Mesa, south rim, JAE 301. Common in the calcareous soils along the south end of the Mesa Verde. Spring.

Haplopappus nuttallii T. &G.
Park Entrance, PRF 2; Rock Canyon, JAE 168; Pine Canyon, WEM 2115. Occasional along the canyon rims and on talus slopes. Summer.

**Helianthus annuus* L. Common sunflower
Park Point, WAW 5228; Wetherill Burn, Rock Springs, JAE 113. Common in disturbed sites. Summer.

Helianthus petiolaris Nutt.
Confluence of Navajo and Spruce Canyons, SN 1736. Disturbed sites. Summer.

Hymenopappus filifolius Hook.
Confluence of Wickiup and Navajo Canyons, SN 1631; Soda Canyon, EHB 128; Chapin Mesa, south rim, JAE 324; Navajo Canyon, SLW 1747. Canyons and lower mesa tops; occasional. Spring.

Hymenoxys acaulis (Pursh) Parker
Chapin Mesa, Sun Temple, EHB s. n.; Park Point, M. E. C. (surname unknown) s. n.; Prater Canyon, MVEC 82; Chapin Mesa, Headquarters, WW 1538; Wetherill Mesa, North Rim, JAE 132; Chapin Mesa, south rim, JAE 311; Park Point, WEM 2086. Common throughout the Mesa Verde. Spring-summer.

Hymenoxys richardsonii (Hook.) Ckll. var. *floribunda* (A. Gray) Parker
Big Mesa, JAE 398; Mancos Canyon, WEM 2163. Occasional; disturbed pinyon-juniper woodland. Summer.

Iva axillaris Pursh Povertyweed
Mancos Canyon, WEM 2153. Common along Mancos River. Summer.

Iva xanthifolia Nutt.
Park Point, WAW 5229. Occasional in disturbed soils. Summer.

Lactuca pulchella (Pursh) DC.
Wild lettuce
Morfield Canyon, EHB s.n. Occasional weed; brush zone. Summer.

Lactuca scariola L.
Little Soda Canyon, PRF 1815. Occasional weed; brush zone. Summer.

Lygodesmia grandiflora (Nutt.) T. & G.
Skeleton plant
Mancos Canyon, WEM 2169. Occasional in disturbed pinyon-juniper woodland along Mancos River. Summer.

Senecio eremophilus Richards. Groundsel
Prater Canyon, EHB 300.

Senecio longilobus Benth.
Wetherill Burn, Rock Springs, JAE 107. Rare; occurring in burned areas at the higher elevations. Summer.

Senecio multilobatus T. & G. ex A. Gray
Wickiup Canyon, PRF 1637; Cedar Tree Tower, MVEC 2; Navajo Canyon MVEC 108; Chapin Mesa, Headquarters, WW 1539; Rock Canyon, JAE 67, 107; Wetherill project laboratory, JAE 292; Chapin Mesa, south rim, JAE 325. Occasional throughout the pinyon-juniper forest. Summer.

Senecio mutabilis Greene
Navajo Canyon, S 1598; ridge between Morfield and Prater Canyons, EHB s. n.; Cedar Tree Tower, MVEC 2a; Morfield Canyon, MVEC 97; Wetherill Mesa, Bobcat drainage, JAE 19; Wetherill Project laboratory, JAE 316; Chapin Mesa, north end, WW 1529. Occasional throughout the pinyon-juniper forest. Summer.

Solidago petradoria Blake ex Tidestr.
Rock goldenrod
Morfield Canyon, EHB 192; Chapin Mesa, EHB 236; Soda Canyon Tipoff, MVEC 44; Far View Group, MVEC 219; Wetherill Mesa, North Rim, JAE 114. Common, especially in the openings of the shrub zone. Summer.

Solidago sparsiflora A. Gray
Soda Canyon, EHB 239; Rock Canyon, JAE 88, WE 1624. Common along the channel bottoms in the canyons. Summer.

Sonchus aspera (L.) Hill Sow thistle
Confluence of Navajo and Spruce Canyons, PRF 1595a; Rock Canyon JAE 92. A weed occurring occasionally in moist, open sites. Summer.

Stephanomeria tenuifolia (Torr.) Hall
Wirelettuce
Chapin Mesa, Oak Tree House, EHB 224; Wetherill Mesa, ruin No. 12, JAE 102; Long House, JAE 235; Step House, SLW 1848. Common along cliffs and ledges. Summer.

Taraxicum officinale Wiggars Dandelion
Park Point, M. E. C. (surname unknown) s. n. An old World weed; common only in moist sites. Spring-summer.

Tetradymia canescens DC.
Gray horsebrush
Chapin Mesa, EHB 230; Wetherill Mesa, North Rim, JAE 109. Occasional in the openings of the brush zone. Summer.

Townsendia exscapa (Richards.) Porter
Head of Bobcat Canyon, JAE 75; Wetherill Mesa, south end, WW 1552, Rare; pinyon-juniper forest. Spring.

Townsendia incana Nutt. Easter daisy
Spruce Tree Canyon, SN 1570a, EHB 122; Soda Canyon Tipoff, MVEC 39; Rock Canyon, ruin No. 12, JAE 193; Chapin Mesa, south rim, JAE 310, 322; Pine Canyon, WEM 2137. Occasional in pinyon-juniper forest. Spring.

Tragopogon pratensis L. Salisify
Long Canyon, SN 1780; Prater Canyon, EHB 176; Rock Springs, MVEC 131; Rock Canyon, JAE 62; Wetherill Project laboratory, JAE 383; Morfield Canyon, WEM 2062. An Old World weed; common besides roads and elsewhere. Summer-autumn.

Verbena encelioides (Cav.) B. & G. ex A. Gray
Morfield Canyon, EHB 206; Wetherill Project Laboratory, JAE 230; Far View Group, SLW 1852. Locally abundant in wet seasons. Summer-autumn.

Viguiera multiflora (Nutt.) Blake
Goldeneye
Far View Group, SLW 1855. Common in successional stands in the shrub zone; occasional elsewhere. Summer-autumn.

Wyethia arizonica A. Gray
Park Point, SN 1595; Spruce Tree Canyon, PRF 1800; Navajo Hill MVEC 62; Wetherill Mesa, North Rim, JAE 149; Chapin Mesa, North Rim, JAE 367. Common in opening along the North Rim. Spring.

Convolvulaceae — Morning-glory Family

Convolvulus arvensis L. Bindweed
Mancos Canyon, WEM 2170. An Old World weed. Summer.

Crassulaceae — Orpine Family

Sedum stenopetalum Pursh Stonecrop
Prater Canyon, MVEC 86. Rare. Summer.

Cruciferae — Mustard Family

Arbis drummondii A. Gray Rockcress
Morfield Canyon, WEM 2064. Summer.

Arabis fendleri (S. Wats.) Greene
Bobcat Canyon, JAE 49; Chapin Mesa, Headquarters, WEM 2111. Summer.

Arabis hirsuta (L.) Scop.
Morfield Canyon, PRF 1819. Summer.

Arabis holboellii Hornem.
Morfield Canyon, WEM 2058; Chapin Mesa, Headquarters, WEM 2109. Occasional. Summer.

Arabis lignifera A. Nels.
Chapin Mesa, Headquarters, SN 1710. Spring-Summer.

Arabis pulchra M. E. Jones ex S. Wats.
Mancos Canyon rim, M. E. C. (surname unknown) s.n.; Chapin Mesa, south end, JAE 266. Under pinyon-juniper on calcareous soil. Spring.

Arabis selbyi Rydb.
Spruce Tree Canyon, EHB 16; Wetherill Mesa, south end, JAE 213; Navajo Canyon, JAE 253; Chapin Mesa, south end, JAE 271; Pine Canyon, WEM 2124; Wetherill Mesa north end, WEM 2200. Common throughout the Mesa Verde under pinyon-juniper. Spring.

Camelina microcarpa Andrz. False flax
Chapin Mesa, Headquarters, SN 1688; Morfield Canyon, EHB 98; Confluence of Navajo and Wickiup Canyons, JAE 348. Adventive along trailsides and other disturbed sites. Spring.

Capsella bursa-pastoris (L.) Medic. Shepherd's purse
Chapin Mesa, Headquarters, SLW 2216. An Old World weed; uncommon. Spring.

Cardaria draba (L.) Desv. Whitetop
Mancos Canyon, WEM 2151. Locally common along the Mancos River; introduced from the Old World. Summer.

Chorispora tenella DC.
Navajo Canyon, JAE 258; Spruce Canyon, JAE 354. A trailside weed; introduced from the Old World. Spring.

Descurainia pinnata (Walt.) Britt. Tansy mustard
Chapin Mesa, Headquarters, SN 1751; Soda Canyon, EHB 47; Chapin Mesa, south end, JAE 268. Comon in disturbed sites. Spring.

Descurainia sophia (L.) Webb. ex Engler & Prantl
Morfield Canyon, MVEC 99; Wetherill Mesa, North Rim, JAE 137; Park Point, JAE 335. A robust weed in disturbed sites. Spring-summer.

Draba reptans (Lam.) Fern. Whitlow wort
Long House, JAE 40; Wetherill Mesa, North Rim, JAE 197; Chapin Mesa, south end, JAE 252; Navajo Canyon, JAE 295. An abundant spring annual in the pinyon-juniper forest throughout the Mesa Verde.

Erysimum inconspicuum (S. Wats.) MacM. Wallflower
Morfield Canyon, EHB 294. Rare. Spring.

Lepidium campestre (L.) R. Br. Pepperweed
Chapin Mesa, Headquarters, WEM 2096. Moist drainage; rare. Summer.

Lepidium densiflorum Schrad.
Far View Group, SN 1679; Spruce Canyon, EHB 146. An annual plant which varies in abundance with varying moisture; occasional. Spring.

Lepidium montanum Nutt. ex T. & G.
Morfield Canyon, PRF 21; Step House, JAE 78; Rock Canyon, ruin No. 12, JAE 101; Long House, JAE 234, SLW 1851. Common throughout the Mesa Verde, but especially abundant on trash slopes and backfill of prehistoric sites. Summer.

Lesquerella rectipes Woot. & Standl.
Bladderpod
Spruce Tree House, SN 1563; Soda Canyon Tipoff, MVEC 45; Chapin Mesa, south rim, JAE 308; Chapin Mesa, Headquarters, WEM 2104. Southern parts of the Mesa Verde; canyons and open sites on calcareous soil. Spring.

Physaria australis (Pays.) Rollins
Double bladderpod
Park Point, MVEC 122; Mug House, JAE 26; Chapin Mesa, south end, JAE 267, 323. Occasional throughout the Mesa Verde; especially on mesa rims and in the canyons. Spring.

Raphanus raphanistrum L. Wild radish
Navajo Canyon, EHB 274. Rare.

Rorippa obtusa (Nutt.) Britt.
Chapin Mesa, Headquarters, WEM 2090. Occasional; moist drainage. Summer.

Sisymbrium altissimum L. Tumbling mustard
Rock Canyon, Long House draw, JAE 63; Wetherill Project laboratory, JAE 317. A robust weed introduced from Europe; disturbed sites. Spring.

Sisymbrium linifolium Nutt.
Spruce Tree House, SN 1562; Morfield Canyon, EHB 95; Wetherill Project laboratory, JAE 315. A plant of disturbed or open sites; occasional. Spring.

°*Stanleya pinnata* (Pursh) Britt.
Prince's plume
Chapin Mesa, Balcony House, SN 1742; Wickiup Canyon, EHB 189; Soda Canyon Tipoff, MVEC 42; Long House draw, JAE 55; Spruce Tree Canyon, WEM 2077. Occasional in canyons on shale outcrops. This plant is an indicator of seleniferous soils (Cannon, 1952). Spring-summer.

Stanleyella wrightii (A. Gray) Rydb.
Confluence of Spruce Tree and Spruce Canyons, PRF 1804. Rare.

Streptanthus cordatus Nutt. Twistflower
Navajo Canyon, SN 1741; Soda Canyon, EHB 57; Chapin Mesa, Headquarters, PRF 2066; Navajo Hill, MVEC 265; ruin No. 12, JAE 199; Chapin Mesa, south rim. JAE 284, 319. Common; especially in the southern parts of the Mesa Verde and on canyon slopes. Spring.

Thlaspi alpestre L. Wild candytuft
Navajo Canyon, SN 1626, EHB s.n.; Rock Canyon, Kodak House, JAE 198. Occasional throughout the Mesa Verde; especially along the North Rim. Spring.

Thelepodium rhomboideum Greene
Confluence of Spruce and Spruce Tree Canyons, PRF 1804; Rock Springs, MVEC 143, JAE 395. Occasional in canyons and draws, usually under oak thickets. Summer.

CYPERACEAE — Sedge Family

Carex geyeri Boott. Elk sedge
Rock Springs draw, JAE 187. Common under oak thickets along the North Rim and in side canyons and draws. Summer.

Carex deweyana Schw.?
Pine Canyon, WEM 2117.

Carex festivella Mack.
Spruce Canyon, EHB 146a.

Carex heliophila Mack.
Morfield Canyon, EHB 102, 162.

Carex occidentalis Bailey
Spruce Canyon, EHB 107; Morfield Canyon, WEM 2061; Pine Canyon, WEM 2135. Occasional in mesic sites; canyon bottoms and slopes. Summer.

Carex praegracilis Boott.
Navajo Canyon, EHB 91; Prater Canyon, WEM 2056. Summer.

Carex sp.
Navajo Canyon, JAE 273; Pine Canyon, WEM 2134.

Eleocharis macrostachya Britt. ex Small
Spikesedge
Mancos Canyon, WEM 2157, 2161. Common on streamside gravels. Summer.

Scirpus americanus Pers. Bulrush
Mancos Canyon, WEM 2155. Common along Mancos River. Summer.

Scirpus paludosus A. Nels.
Rock Canyon, JAE 174. Apparently rare, this collection taken from an extensive spring site; an emergent. Summer.

Scirpus vallidus Vahl.
Mancos Canyon, WEM 2156. Occasional along Mancos River. Summer.

ELEAGNACEAE — Oleaster Family

Shepherdia argentea (Pursh) Nutt.
Buffaloberry
Without collector or locality, s. n. (Mesa

Verde herbarium). Common along the Mancos River at the east boundary of the Park. Spring.

Euphorbiaceae — Spurge Family

Euphorbia fendleri T. & G. Spurge
Chapin Mesa, south rim, JAE 307, 321. Common in the open pinyon-juniper woodland on calcareous soils. Spring-summer.

Euphorbia robusta (Engelm.) Small
Spruce Tree House, SN 1662; Navajo Canyon, EHB 251; Bobcat Canyon, JAE 48; Pine Canyon, WEM 2130. Under thickets and along moist cliffs in shaded side canyons. Summer.

Fagaceae — Beech Family

Quercus ajoensis Muller Ajo oak
Bobcat Canyon rim, JAE 95, WE 1611. Rare; restricted to a few small clones in xeric rimrock sites. Formerly believed to be endemic to the Ajo Mountains of southwestern Arizona (Erdman, et al., 1962).

°*Quercus gambelii* Nutt. Gambel oak
Navajo Canyon, EHB 271, 272; Cedar Tree Tower, MVEC 6; Far View Group, MVEC 222; Park Point, JAE 333; Wetherill Mesa, north end, WW 1532. The common oak of the Mesa Verde, but especially abundant and dominant in the shrub zone along the North Rim. Spring.

°*Quercus gambelii* Nutt. X *Q. turbinella* Greene Wavy-leaf oak
Long House, SLW 1764; Wetherill Mesa, south end, WEM 2185, 2190. These specimens are not at all uniform and may represent crosses with other species; combinations between *Q. gambelii* and *Q. ajoensis* or between *Q. gambelii* and *Q. havardii* are also possible. Rare; primarily on rimrock along the south end of the Mesa Verde. Spring.

Quercus turbinella Greene X *Q. ajoensis* Muller
Chapin Mesa, Thomas House, JAE 220. Rare; this clone occurring on the mesa rim. Spring.

Fumariaceae — Fumitory Family

Corydalis aurea Willd. Goldensmoke
Confluence of Navajo and Wickiup Canyons, SN 1649; Spruce Canyon, EHB 12. Rare; open sandy areas. Spring-summer.

Gentianaceae — Gentian Family

Swertia albomarginata (S. Wats.) Kuntze Green gentian
Soda Canyon Tipoff, MVEC 34; ruin No. 12, WE 1617. Occasional in the southern part of Mesa Verde on calcareous soils. Spring.

Geraniaceae — Geranium Family

Erodium cicutarium (L.) L'Her Storksbill
Chapin Mesa, Headquarters, SN 1691; Wetherill Project laboratory, JAE 264. A prostrate weed on disturbed sites. Spring-summer.

Geranium caespitosum James
Morfield Canyon, EHB 202; Rock Springs, JAE 397. Occasional in draws and side canyons. Summer.

Gramineae — Grass Family

Agropyron desertorum (Fisch.) Schult. Crested wheatgrass
Morfield Burn, JAE 212. Introduced in burned areas in an attempt to check erosion; an Old World grass. Summer.

Agropyron intermedium (Host.) Beauv. Intermediate wheatgrass
Morfield Burn, JAE 210; Wetherill Project laboratory, JAE 386. Introduced in burned areas, but also common beside roads; an Old World grass. Summer.

Agropyron smithii Rydb. Western wheatgrass
North Rim, EHB 181; Morfield Canyon, MVEC 2; Park Point, MVEC 165; Wetherill Mesa, North Rim, JAE 146; Bobcat drainage, JAE 182; Navajo Canyon, JAE 378. Common; especially in North Rim saddles. Summer.

Agropyron trachycaulum (Linke) Malte Slender wheatgrass
Far View Group, SN 1781; Spruce Canyon, EHB 118; Rock Canyon, JAE 172; Spruce Canyon, WEM 2075, 2080. Occasional in canyon bottoms; usually in shaded areas. Summer.

Agrostis alba L. Redtop
Fewkes Canyon, EHB 256; Chapin Mesa, Headquarters, SLW 2210. Locally common in moist areas; an Old World grass. Summer.

Aristida fendleriana Steud. Three-awn
Wetherill Mesa, south end, JAE 216; Chapin Mesa, Pool Canyon, WEM 2178. Occasional on the mesas in the southern part of Mesa Verde. Summer.

Avena fatua L. Wild oat
Park Point, WAW 5232. An Old World adventive in disturbed sites. Summer.

Bouteloua curtipendula (Michx.) Torr. ex Emory Sideoats grama
Mancos Canyon, Two-story Cliff House, JAE 409. Dry, open ledges; rare. Summer.

Bouteloua gracilis (H. B. K.) Lag. ex Steud. Blue grama
Morfield Canyon, EHB 268; Moccasin Mesa, south rim, JAE 249. Occasional throughout the Mesa Verde; more common in moist years. Summer.

Bromus anomalus Rupr. ex Fourn. Nodding brome
Spruce Canyon, EHB 119.

Bromus carinatus Hook. & Arn. California brome
Morfield Burn, JAE 211. Occasional in disturbed sites. Summer.

Bromus inermis Leyss. Smooth brome
Rocks Springs, MVEC 137; Wetherill Burn JAE 152; Wetherill Mesa, Bobcat drainage, JAE 181; Morfield Burn, JAE 358. Introduced in burned area, but also common along roads; an Old World grass. Summer.

Bromus japonicus Thunb. Japanese chess
Morfield Burn, JAE 209; Chapin Mesa, Headquarters, WEM 2107; Mancos Canyon, WEM 2166. An introduced weed of disturbed sites. Summer.

Bromus tectorum L. Cheatgrass
Chapin Mesa, Sun Temple, EHB 80; Mancos Canyon, MVEC 37; Wetherill Mesa, North Rim, JAE 145; Wetherill Project laboratory, JAE 372. An introduced weed under big sagebrush in canyon bottoms and waste places. Spring.

Dactylis glomerata L. Orchard grass
Far View Group SN 1685; Navajo Canyon, MVEC 121; Spruce Tree Canyon WEM 2071. Introduced; occasional in shaded waste places. Summer.

Elymus salinus M.E. Jones Wild rye
Wetherill Mesa, North Rim, JAE 3, WEM 2197; Chapin Mesa, south end, SLW 1744. Rare; rocky places. Summer.

Festuca octoflora Walt. Six-weeks fescue
Pool Canyon, WEM 2177. A winter annual; pinyon-juniper woodland. Spring.

Hilaria jamesii (Torr.) Benth. Galleta
Moccasin Mesa, Spencer G-107; Navajo Canyon, JAE 376. Common on shale outcrops in canyons and dry, open sites to the south. Spring.

Hordeum jubatum L. Foxtail barley
Morfield Canyon, MVEC 92; Chapin Mesa, Headquarters, WAW 5230, WEM 2110; Rock Canyon, JAE 169. Restricted to moist habitats. Summer.

Hordeum pusillum Nutt. Little barley
Spruce Tree Canyon, EHB 145.

Koeleria cristata (L.) Pursh Junegrass
North Rim, SN 1758; Morfield Canyon, MVEC 96, WEM 2065; Park Point, MVEC 156; Wetherill Mesa, North Rim, JAE 141, WEM 2199; Long Canyon, West Fork, JAE 159. Common in the northern part of the Mesa Verde. Summer.

Muhlenbergia andina (Nutt.) Hitchc. Foxtail muhly
Oak Tree House, EHB 321.

°*Muhlenbergia richardsonis* (Trin.) Rydb. Mat muhly
North Rim, B Cut, WAW 5241. Sandstone ledge. Summer-autumn.

°*Oryzopsis hymenoides* (R. & S.) Ricker Indian ricegrass
Spruce Canyon, SN 1663; Soda Canyon Tip-off, MVEC 43; Rock Canyon, ruin No. 16 draw, JAE 70; Rock Canyon JAE 85; Wetherill Project laboratory, JAE 385. Abundant in Canyon bottoms and draws; elsewhere common in disturbed sites and waste places. Summer.

Oryzopsis micrantha (Trin. & Rupr.) Thurb. Littleseed ricegrass
Navajo Canyon, JAE 218; Pine Canyon, WEM 2116. Shaded, moist habitats. Summer.

Phleum pratense L. Timothy
Cliff Palace, EHB 219. An adventive in waste areas. Summer.

°*Phragmites communis* Trin. Common reed
Rock Canyon, ruin No. 12, JAE 166, 176. Occasional throughout the Mesa Verde near seeps and springs. Summer-autumn.

Poa annua L. Annual bluegrass
Chapin Mesa, Headquarters, SLW 2215. Locally common in moist areas; adventive. Summer.

Poa compressa L. Canada bluegrass
Cliff Canyon, Cliff Palace, EHB 220; Long Canyon, West Fork, JAE 158. Occasional in moist habitats. Summer.

Poa fendleriana (Steud.) Vasey Mutton grass
Lower Soda Canyon, EHB 58; Navajo Canyon, EHB 84; Cliff Canyon, EHB s. n.; Rock Canyon, ruin No. 12 draw, JAE 203; Wetherill Project laboratory, JAE 263; Far View Group, WW 1534. The dominant grass throughout the Mesa Verde; a major component of the climax pinyon-juniper forest on deep loess soils. Spring.

Poa longiligula Scribn. & Will.
Spruce Canyon, EHB 14. Spring.

Poa pratensis L. Kentucky bluegrass
Morfield Canyon, SN 1754, EHB 291, WEM 2067; Navajo Canyon, Ross and Sylvus s. n.; Rock Canyon, JAE 173; Far View Group, WW 1537. Occasional in moist habitats. Summer.

Poa secunda Presl. Sandberg bluegrass
Balcony House, SN 1699; Confluence of Navajo and Wickiup Canyons, JAE 347; Morfield Canyon, JAE 382; Spruce Tree Canyon, WEM 2079. Occasional along the talus slopes and canyon bottoms. Spring.

Polypogon monspeliensis (L.) Desf. Beardgrass
Rock Canyon, ruin No. 12, JAE 170. Moist habitat; alkaline spring. Summer.

Puccinellia distant (L.) Parl. Alkali grass
Morfield Canyon, MVEC 90; Rock Canyon, JAE 171; Mancos Canyon, WEM 2158. Moist habitat; seeps, drainages and ditches. Summer.

Secale cereale L. Rye
Mug House, SLW 1758. Introduced on recently excavated trash slopes. Summer-autumn.

Sitanion hystrix (Nutt.) J. G. Smith Squirreltail
Far View Group, SN 1680; The Glades EHB 124; North Rim, MVEC 123; Wetherill Mesa, North Rim, JAE 142; Long Canyon, West Fork, JAE 160; Wetherill Mesa, Bobcat drainage, JAE 183; Navajo Canyon, JAE 377; Prater Canyon, WEM 2068. Common in canyons and drainages, and in the shrub zone. Summer.

Sporobolus cryptandrus (Torr.) A. Gray Sand dropseed
Pine Canyon, Spencer G-32; Mancos Canyon, Two-story Cliff House, JAE 402. Occasional in the mesa-top pinyon-juniper forest. Summer-autumn.

Stipa comata Trin. & Rupr. Needle-and-thread
Prater Canyon, SN 1722; North Rim, SN 1726; Navajo Canyon, MVEC 120; Park Point, MVEC 164; Wetherill Mesa, North Rim, JAE 143; Long House, JAE 177; Wetherill Project laboratory, JAE 384. Common along the North Rim; elsewhere an indicator of disturbed sites. Summer.

Stipa speciosa Trin. & Rupr. Desert needlegrass
Rock Canyon, ruin No. 12, JAE 97, 165. Rare, restricted to cliff ledges. Summer.

Triticum aestivum L. Wheat
Morfield Burn, JAE 208. An adventive, probably escaped cultivation. Summer.

Hydrophyllaceae — Waterleaf Family

Ellisia nyctelea L.
Confluence of Wickiup and Navajo Canyons, SN 1648; Spruce Canyon, EHB 138. Occasional in disturbed soils. Summer.

Phacelia heterophylla Pursh Scorpion weed
Far View Group, SN 1672, MVEC 50; Wetherill Mesa, North Rim, JAE 135; Rock Springs draw, JAE 393. Occasional; saddles and drainages along North Rim. Summer.

Phacelia splendens Eastw.
Jackson Butte, west escarpment, JAE 274; Point Lookout, SLW 1756. Restricted to the Mancos shale formation below the north and west rims. Spring.

Iridaceae — Iris Family

Iris missouriensis Nutt.
Prater Canyon, SN 1712; EHB 177, JAE 379, WEM 2054; Morfield Canyon, MVEC 14. Restricted to wet meadows in Prater and Morfield Canyons. Summer.

Juncaceae — Rush Family

Juncus balticus Willd. Baltic rush
Navajo Canyon, EHB 94; Morfield Canyon, JAE 381; Prater Canyon, WEM 2055; Chapin Mesa, Headquarters, WEM 2092. Common in moist areas; especially in Prater and Morfield Canyons. Summer.

Juncus longistylis Torr. Long-styled rush
Chapin Mesa, Headquarters, WEM 2102. Common; moist drainage. Summer.

Juncus saximontanus A. Nels f. *brunescens* (Rydb.) Herm.
Chapin Mesa, Headquarters, WEM 2106. Common; moist drainage. Summer.

Juncus tenuis Willd. Slender rush
Chapin Mesa, Headquarters, WEM 2105. Common; moist drainage. Summer.

JUNCAGINACEAE — Arrowgrass Family

Triglochin maritima L. Arrowgrass
Mancos Canyon, WEM 2163. Restricted to the gravel beds of Mancos River. Summer.

LABIATAE — Mint Family

Marrubium vulgare L. Hoarhound
Chapin Mesa, Headquarters, WEM 2087. An introduced mint. Rare.

Moldavica parviflora (Nutt.) Britt. False dragonhead
Confluence of Wickiup and Navajo Canyons, SN 1646; Spruce Canyon, EHB 143; Navajo Canyon, MVEC 110; Rock Springs, MVEC 148; Wetherill Mesa, North Rim, JAE 138; Morfield Canyon, WEM 2059. Occasional in canyon bottoms and in the saddles along the North Rim. Summer.

°*Salvia reflexa* Hornem. Lancelcaf sage
Chapin Mesa, Headquarters, PRF 1816. Rare. Summer.

LEGUMINOSAE — Pea Family

Astragalus bisulcatus (Hook.) A. Gray var. *haydenianus* (A. Gray) Barneby Milkvetch
Point Lookout, SLW 1752. Occasional; seleniferous shales below Point Lookout and along Mancos River. Summer.

Astragalus calycosus Torr. ex S. Wats.
Mancos Canyon, M. C. (surname unknown) s.n.; Chapin Mesa, south rim, JAE 191, 265, 327, WEM 1743. Common on calcareous soils in the southern part of the Mesa Verde. Spring.

Astragalus deterior (Barneby) Barneby
Chapin Mesa, Cliff Palace, Ripley and Barneby 5359 (Holotype, *A. deterior*); Sun Temple, Ripley and Barneby 8397 (Paratype, *A. deterior*); Moccasin Mesa, south rim, JAE 248, 371; Navajo Canyon, SLW 1746; Pine Canyon, WEM 2132. Known only from the Mesa Verde, where it is restricted to rimrock and talus slope situations (Barneby, 1948; Barneby, 1953). Spring.

Astragalus flexuosus (Hook.) Don
Navajo Canyon, JAE 373; SLW 1745; ruin No. 12, WW 1553, SLW 1763. A glabrous form of the species, occasional along talus slopes and canyon bottoms. Spring-summer.

Astragalus humillimus A. Gray ex Brandegee
A Mesa Verde endemic which has not been found since it was collected by T. S. Brandegee (Hayden Survey, 1876) "Growing upon sandstone rock of the Mesa Verde, near the edge of the Mancos Canyon." The Brandegee specimens are located in the collections of the New York Botanical Garden and of the Gray Herbarium (Barneby, 1948). Weber has reproduced the original description of the species (1961).

Astragalus lentiginosus Dougl. var. *diphysus* (A. Gray) M. E. Jones
Wickiup Canyon, SN 2038; Long House, JAE 206, WW 1551, SLW 1657; Navajo Canyon, JAE 272; Spruce Tree Canyon, JAE 355. Canyon slopes; occasional. Spring, autumn.

Astragalus lonchocarpus Torr.
Confluence of Navajo and Wickiup Canyons, JAE 351. Rare.

Astragalus missouriensis Nutt. var. *missouriensis*
Soda Canyon, EHB 53; Pine Canyon, WEM 2131. The position of the former specimen in this variety is in doubt. It is in flower only and the mature fruit is diagnostic. The latter specimen has the straight pods characteristic of the variety. Locally common along the rimrock at Pine Canyon. Spring.

Astragalus missouriensis Nutt. var. *amphibolus* Barneby
Mancos, Montezuma Co., Colorado, Baker, Earle and Tracy 56 (Herbarium, New York Botanical Garden; Holotype, var. *amphibolus*); Mancos Canyon, WEM 2167. The pods of the latter specimen are strongly curved and ovoid. They are characteristic of the variety (Barneby, 1947). Occasional; Mancos Canyon. Spring.

Astragalus pattersonii A. Gray
Base of Point Lookout, JAE 287, SLW 1754; Park Entrance, WW 1561. A white-flowered, clump-forming plant restricted to the seleniferous Mancos shale formation below the North Rim; locally abundant. Spring.

Astragalus schmollae C. L. Porter
Spruce Tree House, SN 1555 (Holotype, *A. schmollae*, Rocky Mountain Herbarium; Isotype, Mesa Verde herbarium); Cliff Canyon, EHB 26; Chapin Mesa, Headquarters, WAW 4283, WW 1550. Endemic to the Mesa Verde. It occupies a very limited area in the pinyon-juniper forest around Park Headquarters (Porter, 1945). Spring-summer.

Astragalus scopulorum T. C. Porter
Spruce Tree House, SN 1555a; Far View Group, MVEC 55; Park Point, MVEC 159; Wetherill Mesa, North Rim, JAE 4, WEM 2198; Chapin Mesa, ruins road, JAE 300; Park Point, JAE 332; Chapin Mesa, Headquarters, WW 1543. The most common *Astragalus* in the Mesa Verde; especially abundant along the North Rim. Spring-summer.

Astragalus wingatanus S. Wats.
Soda Canyon, EHB 38; Chapin Mesa, south rim, JAE 309; Chapin Mesa, Headquarters, WW 1544; Base of Point Lookout, SLW 1753. Occasional pinyon-juniper forest. Summer.

Hedysarum boreale Nutt. Sweetvetch
Morfield Canyon, EHB 158; Park Point, WEM 2082. Rare; North Rim. Summer.

Lathyrus eucosmus Butters & St. John Sweetpea
Mancos Canyon, SLW 1761. Clay soils near Mancos River. Spring.

Lathyrus leucanthus Rydb. var. *laetivirens* (Rydb.) Hitchc.
North Rim, B Cut, WEM 2149; Big Mesa, SLW 1760. Rare; North Rim. Spring-summer.

Lathyrus leucanthus Rydb. X L. *pauciflorus* Fern.
Spruce Canyon, JAE 353 (corolla white with purple streaks); North Rim, B Cut, WEM 2150. The latter specimen is nearer to *L. leucanthus* but other white-flowered specimens in the vicinity have the large broad stipules of *L. pauciflorus*. Common along the North Rim. Spring-summer.

Lathyrus pauciflorus Fern.
Between Little Soda and Soda Canyons, SN 1577a; Navajo Hill, MVEC 64 (white flowers); Navajo Canyon, MVEC 118; Wetherill Mesa, North Rim, JAE 148; Rock Springs draw, JAE 189; Park Point, JAE 330, WW 1528. Common under oak thickets of the North Rim. Spring.

Lupinus ammophilus Greene Sand lupine
North Rim, SN 1763; Navajo Canyon, without collector, s.n. (Mesa Verde herbarium); Rock Springs, MVEC 139; Long House, JAE 179; Wetherill Project laboratory, JAE 313. Occasional in pinyon-juniper forest. Spring.

Lupinus caudatus Kell. Spurred lupine
Spruce Tree House, SN 1562a; Far View Group, SN 1673, MVEC 49; Morfield Canyon, EHB 284, MVEC 18; Park Point, MVEC 162; Rock Canyon, JAE 64, 84; Bobcat drainage, JAE 116; Morfield Burn, JAE 356; Chapin Mesa, Headquarters, WW 1549. Common throughout the northern part of Mesa Verde; abundant along North Rim. Summer.

Melilotus alba Desf. ex Lam. White sweetclover
North Rim, PRF 1802. Trail and roadside weed; adventive, Summer.

Melilotus officinalis (L.) Lamb. Yellow sweetclover
Rock Springs, MVEC 145; Rock Canyon, JAE 65; Wetherill Project laboratory, JAE 360. Same habitat as *M. alba*, but more common. Summer.

Medicaga lupulina L. Black medic
Chapin Mesa, Headquarters, WEM 2093. An Old World adventive; moist waste places. Summer.

Thermopsis montana Nutt. Golden banner
Prater Canyon, SN 1705. Rare; occurring in moist sites in the Prater-Morfield Canyon area. Summer.

Trifolium pratense L. Red clover
Mancos Canyon, WEM 2159. Introduced forage plant; escaped from cultivation. Summer.

Trifolium repens L. White Dutch clover
Prater Canyon, EHB 175; Mancos Canyon, WEM 2152. Introduced forage plant; escaped from cultivation. Summer.

Vicia americana Muhl. Common vetch
Park Point, PRF 26; Morfield Canyon, JAE 361. Under thickets in shrub zone along the North Rim. Spring.

Liliaceae — Lily Family

Allium acuminatum Hook. Wild onion
North Rim, MVEC 76; Rock Springs, JAE 29; Pool Canyon, WEM 2179. Occasional; sandy soils. Summer.

°*Allium textile* Nels. & Macbr.
Jackson Butte, west escarpment, JAE 276. Restricted to the Mancos shale slopes below the Mesa Verde. Spring.

Androstephium breviflorum S. Wats. Funnellily
Mancos Canyon, WEM 2171. Rare; pinyon-juniper woodland along the Mancos River Spring.

Calochortus gunnisonii S. Wats. Mariposa lily
Chapin Mesa, EHB 127; Rock Springs, MVEC 125; Bobcat drainage, JAE 79; Wetherhill Mesa, North Rim, JAE 144, WEM 2193. Occasional; primarily in the shrub zone on the mesa tops. Summer.

Calochortus nuttallii Torr. Sego lily
The Glades, EHB 123; Bobcat drainage, JAE 18; Wetherill Mesa, North Rim, JAE 130; Morfield Burn, JAE 380; Spruce Tree Canyon, WEM 2072. Habitat similar to that for *C. gunnisonii*. Summer.

Fritillaria atropurpurea Nutt. Fritillary
No specimen has been seen. There is a note in the Mesa Verde herbarium which indicates that a specimen of this species was collected by P. R. Franke on May 25, 1933.

Smilacina racemosa (L.) Desf.
False Soloman's seal
Prater Canyon, SN 1718; EHB 209. Moist, shaded woodlands; North Rim. Spring.

Smilacina stellata (L.) Desf.
Prater Canyon, SN 1716, EHB 62; Pine Canyon, WEM 2121. Shaded woodlands, especially along canyon bottoms. Spring.

°*Yucca baccata* Torr. Datil yucca
Without locality, SN 1659; Long House, JAE 11; Chapin Mesa, Headquarters, WW 1546. Common in the pinyon-juniper forest throughout the Mesa Verde, both on the mesas and on the canyon slopes. Spring-summer.

°*Yucca harrimaniae* Trel.
Spruce Canyon, SN 1728; Wetherill Mesa, south end, JAE 121. Occasional; open slopes in the canyons and southern parts of the mesas. Spring-summer.

Zygadenus paniculatus S. Wats. Death camas
Navajo Canyon, west of Mummy Lake, SN 1668; Far View Group, PRF 20, JAE 340. Occasional; openings in shrub zone. Spring-summer.

LINACEAE — Flax Family

Linum perenne L. Wild flax
Far View Group, SN 1598, EHB 83; Chapin Mesa, JAE 314; Navajo Canyon, SLW 1749. Ditches beside highway and other moist waste places; locally common. Spring.

LOASACEAE — Loasa Family

Mentzelia albicaulis Dougl. ex Hook. Blazing star
Confluence of Navajo and Wickiup Canyons, SN 1647, EHB 137. Rare

Mentbelia multiflora (Nutt.) A. Gray
North Rim, EHB 215. Rare.

LORANTHACEAE — Mistletoe Family

Arceuthobium campylopodium Engelm. f.*divaricatum* (Engelm.) Gill.
Dwarf mistletoe
Wetherill Mesa, south end, JAE 120, WEM 2186. Host, pinyon pine. This mistletoe is most abundant in the southern parts of the Mesa Verde.

Phoradendron juniperinum Engelm.
Juniper mistletoe
Chapin Mesa, Headquarters, WAW 5225; Long House, JAE 74. Host, Utah juniper. Common throughout the pinyon-juniper forest.

MALVACEAE — Mallow Family

Iliamna rivularis (Dougl.) Greene
Wild hollyhock
Wickiup Canyon, SN 1639; Switchbacks Road, SN 1760; Rock Springs, MVEC 134; below Point Lookout, WEM 2175. Rare; clay soils along entrance road. Summer.

Sphaeralcea coccinea (Pursh) Rydb.
Globe mallow
Wetherill Mesa, North Rim, JAE 10; Chapin Mesa, ruins road, JAE 312. A pioneer in waste places and disturbed sites; common in burned areas. Summer.

Sphaeralcea parvifolia A. Nels.
Confluence of Navajo and Spruce Canyons, SN 1651, 1653; confluence of Navajo and Wickiup Canyons, JAE 352, SLW 1751. A trailside plant occurring in the canyons; occasional. Summer.

NYCTAGINACEAE — Four-O'clock Family

Abronia fragrans Nutt. Sand verbena
Navajo Canyon, SN s. n.; Mancos Canyon, MVEC 40. Occasional in the canyons. Spring, autumn.

Mirabilis multiflora (Torr.) A. Gray ex Torr. Wild four-o'clock
Wetherill Mesa, south end, WEM 2183. Rare; pinyon-juniper woodland, south end of Mesa Verde. Spring.

Mirabilis oxybaphoides A. Gray
Fewkes Canyon, EHB 324; Soda Canyon, Painted Kiva House, JAE 403. Rare. Summer.

Oxybaphus linearis (Pursh) Robins.
Moccasin Mesa, south rim, JAE 400; Pine Canyon, WEM 2136. Rare; southern end of Mesa Verde on rimrock. Summer-autumn.

Oleaceae — Olive Family

Forestiera neomexicana A. Gray Adelia
Confluence of Navajo and Long Canyons, SN 1775; Rock Canyon, JAE 90; WE 1621; Moccasin Mesa, south rim, JAE 370; Pine Canyon, WEM 2125. Somewhat rare; restricted to moist canyon sites. Spring.

Fraxinus anomala Torr. ex S. Wats. Single-leaf ash
Wetherill Mesa, Bobcat spur, JAE 35. Rare; one mature tree on rimrock, and a sapling in bottom of Rock Canyon. Spring.

Onagraceae — Evening Primrose Family

Epilobium paniculatum Nutt. ex T. & G. Autumn willowweed
Moccasin Canyon, PRF 1820; Morfield Canyon, EHB 265; Chapin Mesa, Headquarters, SLW 2209. Locally common in moist situations. Summer.

Gayophytum ramosissimum T. & G.
Morfield Canyon, EHB 205.

Oenothera caespitosa Nutt. var. marginata (Nutt.) Munz Evening primrose
School Section Canyon, SN 1725; Morfield Canyon, MVEC 22; Navajo Hill, MVEC 261; Prater Canyon, JAE 388, WEM 2053. Occasional; canyon bottoms and along the North Rim. Spring-summer.

Oenothera coronopifolia T. & G.
Morfield Canyon, EHB 166, MVEC 88; Moccasin Mesa, south end, JAE 368; Prater Canyon, WEM 2057. Waste places. Spring.

Oenothera flava (A. Nels.) Garrett
Mancos Canyon, WEM 2172. Rare; moist places. Summer.

Oenothera hookeri T. & G.
Chapin Mesa, Headquarters, PRF 1806. Moist waste places. Summer-autumn.

Oenothera pallida Lindl.
Confluence of Navajo and Wickiup Canyons, SN 1745, PRF 1801; Rock Canyon, JAE 87. Occasional in sandy situations. Summer.

Orchidaceae — Orchid Family

Epipactis giganteus Dougl. Heleborine
Ruin No. 12, JAE 103; WE 1614. Rare; restricted to moist, seep walls; only one locality known. Summer.

Plantaginaceae — Plantain Family

Plantago lanceolata L. English plantain
Mancos Canyon, WEM 2164. An Old World weed. Summer.

Plantago major L. Common plantain
Mancos Canyon, WEM 2165. An Old World weed. Summer.

Plantago purshii Roem. & Schult. Wooly plantain
Spruce Canyon, EHB 124, Mancos Canyon, WEM 2168. An annual plantain locally common in Mancos Canyon. Spring-summer.

Polemoniaceae — Phlox Family

Collomia grandiflora Dougl. ex Lindl.
Chapin Mesa, EHB 231; Rock Springs, JAE 156. Occasional; shrub zone. Summer.

Collomia linearis Nutt.
Morfield Canyon, EHB 267, 292; Wetherill Mesa, north end, WEM 2194. Occasional. Summer.

Gilia aggregata (Pursh) Spreng Scarlet gilia
Spruce Tree House, SN 1568; Soda Canyon, EHB 50; Morfield Canyon, MVEC 11; North Rim, MVEC 78; Mug House, JAE 30; Long Canyon, JAE 41; Long House, JAE 54; Navajo Canyon, JAE 349. Common in the canyons and on the mesa rims. Spring-summer.

Gilia haydenii A. Gray
Switchbacks Road, EHB s. n.; Point Lookout, SLW 1755. Restricted to Mancos shale formation at the base of the Mesa Verde. Spring.

Gilia sinuata Dougl. ex Benth.
Chapin Mesa, Headquarters, SN 1693; Rock Springs, JAE 28; Navajo Canyon, JAE 296. A small spring annual, abundant under pinyon-juniper.

Gilia sp.
Jackson Butte, west rim, JAE 275. Restricted to the Mancos shale formation below the Mesa Verde. Spring.

Leptodactylon pungens (Torr.) Rydb. Granite gilia
Balcony House, SN 1700; Long House, JAE 161; Chapin Mesa, south rim, JAE 328. Occasional; canyons and southern parts of mesas. Spring-summer.

Microsteris humilis (Dougl.) Greene
Kodak House, JAE 192; Navajo Canyon, JAE 257, 261; Morfield Canyon, WEM 2060; Chapin Mesa, Headquarters, WEM 2098. A small annual, common throughout the Mesa Verde. Spring.

Phlox hoodii Richards.
Chapin Mesa, Headquarters, SN 1565, M. E. C. (surname unknown) s. n.; Long House, JAE 25; Chapin Mesa, south end, JAE 259. Common in canyons and southern parts of the mesas. Spring.

Phlox longifolia Nutt.
Spruce Tree House, SN 1558; Cliff Canyon, EHB 27; Morfield Canyon, MVEC 94; Chapin Mesa, south end, JAE 299. Occasional throughout the Mesa Verde; common on calcareous soils to the south. Spring.

Polemonium foliosissimum A. Gray. Jacob's ladder
Prater Canyon, EHB 169; Rock Springs, JAE 190. Rare; restricted to moist sandy pockets in drainages. Summer

POLYGONACEAE — Buckwheat Family

°*Eriogonum alatum* Torr. ex Sitgreaves Winged eriogonum
Balcony House, SN 1695; Soda Canyon Tip-off, EHB 129; Cliff Palace, EHB 213; Rock Springs, MVEC 144; Long House, JAE 38; Rock Canyon, JAE 167. Occasional; pinyon-juniper forest throughout the Mesa Verde. Summer.

Eriogonum cernuum Nutt.
Morfield Canyon, EHB 286. Annual. Summer.

Eriogonum corymbosum Benth. ex DC.
North Rim, PRF 4, 6. Restricted to the Mancos shale formation. Autumn.

Eriogonum jamesii Benth.
Cliff Palace, EHB 270; Chapin Mesa, PRF 2138; Rock Springs, MVEC 149; Bobcat Canyon, JAE 118; Navajo Canyon, JAE 225; Long House, SLW 1652. Common; mesa rims and canyons. Summer.

Eriogonum lonchophyllum T. & G.
Switchbacks Road, EHB 214. Rare.

Eriogonum racemosum Nutt.
Soda Canyon, EHB 7; Far View Group, MVEC 225; Wetherill Burn, JAE 124. Common throughout the Mesa Verde. Summer.

Eriogonum simpsonii Benth. ex DC.
Big Mesa, JAE 399. Apparently restricted to the mesas in the extreme eastern part of the Mesa Verde. Summer.

Eriogonum umbellatum Torr. Sulfurflower
Far View Group, SN 1666; MVEC 58; Prater Canyon, MVEC 87; Navajo Canyon, MVEC 114; Park Point, MVEC 152; Navajo Hill, MVEC 263; Wetherill Mesa, North Rim, JAE 115, 133; North Rim, B Cut, WEM 2144. Common throughout the Mesa Verde. Summer.

Polygonum aviculare L. Knotweed
Chapin Mesa, Headquarters, WAW 5235. Adventive. Summer.

Polygonum convolvulus L.
Rock Springs draw, JAE 394. Rare; moist, sandy site. Summer.

°*Polygonum sawatchense* Small
Morfield Canyon, EHB 265; Far View Group, PRF 1671; Rock Springs, JAE 157, 396. A common annual; abundant throughout the Mesa Verde in moist years. Summer.

Rumex crispus L. Curly dock
Chapin Mesa, Headquarters, SN 1788. Adventive. Spring-summer.

Rumex hymenosepalus Torr. Canaigre
Confluence of Spruce and Navajo Canyons, SN 1654, WEM 2087a. Rare; known only from the locality cited. Spring-summer.

PORTULACACEAE — Purslane Family

Claytonia lanceolata Pursh Spring beauty
Confluence of Spruce Tree and Spruce Canyons, EHB 10; Wetherill Mesa, North Rim, JAE 196; Spruce Canyon, JAE 255. Common in spring under oak thickets in side canyons and along the North Rim.

Primulaceae — Primrose Family

Androsace septentrionalis L. Rock jasmine
Wickiup Canyon, SN 1641; Morfield Canyon, MVEC 15; Bobcat Canyon, JAE 23; Wetherill Project laboratory, JAE 289; Chapin Mesa, Headquarters, WEM 2100. Occasional; shaded side canyons and along washes on mesa rims. Spring.

Ranunculaceae — Buttercup Family

Clematis hirstissima Pursh
Prater Canyon, SN 1706; Morfield Canyon, MVEC 17. Rare. Spring.

°*Clematis ligusticifolia* Nutt. ex. T. & G. Virgin's bower
Long Canyon, SN 1781; ruin No. 12, JAE 104. Moist, shaded sites in canyons and draws; somewhat rare. Summer.

Clematis pseudoalpina (Kuntze) A. Nels.
Fewkes Canyon, Fire Temple, SN 1748; North Rim, B Cut, WEM 2138; Wetherill Mesa, North Rim, WEM 2201. Common along cliff below North Rim escarpment. Spring.

Delphinium nelsonii Greene Larkspur
Navajo Hill, MVEC 65, 111; Far View Group, JAE 302; Chapin Mesa, Headquarters, WEM 2101. Common; primarily in the shrub zone in spring.

Ranunculus cymbalaria Pursh Shore buttercup
Prater Canyon, EHB 178; Morfield Canyon, MVEC 19; Mancos Canyon, MVEC 27, WEM 2160; Rock Canyon, JAE 89. Somewhat rare; an emergent restricted to moist sites. Spring.

Ranunculus testiculatus Crantz.
Spruce Canyon, JAE 256. A small spring annual, abundant on canyon trails.

Thalictrum fendleri Engelm. ex A. Gray
Prater Canyon, SN 1714, EHB 170. Rare; moist shaded woods. Spring.

Rhamnaceae — Buckthorn Family

Ceanothus fendleri A. Gray New Jersey tea
Morfield Canyon, EHB 201; North Rim, PFR s. n. Rare.

Rosaceae — Rose Family

°*Amelanchier utahensis* Koehne Utah serviceberry
Switchbacks Road, SN 1762; Cliff Canyon, EHB 25; Soda Canyon Tipoff, MVEC 41; North Rim, MVEC 220; Bobcat Canyon, JAE 50; Spruce Tree Canyon, JAE 374; Park Point, JAE 339, WW 1525; Pine Canyon, WEM 2123. Common throughout the Mesa Verde on shallow soils of mesa rims and ridges, and on canyon slopes; dominant in shrub zone along North Rim. Spring.

Cercocarpus intricatus S. Wats. Mountain mahogany
Wetherill Mesa, south end, JAE 217, WEM 2192. Rare; only one locality known, on exposed rimrock. Spring.

°*Cercocarpus montanus* Raf. Mountain mahogany
Without locality, SN 1572; Soda Canyon, EHB 41; Park Point, MVEC 155; Far View Group, MVEC 221, JAE 342; Wetherill Burn, JAE 108; Chapin Mesa, Headquarters, WW 1541. Common throughout the Mesa Verde on shallow soils in canyons and mesas. Spring.

Cercocarpus montanus Raf. X *C.* sp.
Pine Canyon, JAE 244, WEM 2131a. Rare; only one locality known, on rimrock. This specimen is evergreen and has toothed leaves. It apears to be intermediate between *C. montanus* and *C. ledifolius* Nutt. However, *C. ledifolius* is not known from southwestern Colorado (Harrington, 1954) and it is possible that the plant represents a segregate from a cross between *C. montanus* and *C. intricatus*. Spring.

Cowania mexicana Don Cliffrose
Chapin Mesa, Headquarters, SN 1790, WW 1560; Bobcat Canyon, JAE 32; Chapin Mesa, south rim, JAE 306. Occasional; occurring only on exposed mesa rims. Spring.

Holodiscus dumosus (Nutt.) Heller Rock spirea
Wetherill Mesa, JAE 111. Rare; cliff below North Rim escarpment. Summer.

Peraphyllum ramosissimum Nutt. ex T. & G. Squawapple
Chapin Mesa, Headquarters, SN 1665, WW 1542; Far View Group, MVEC 57; Wetherill Burn, JAE 154; Chapin Mesa, ruins road, JAE 305; Wetherill Mesa, south end, WEM 2191. Occasional throughout the Mesa Verde; more common near the North Rim and abundant on north- and east-facing clay slopes of the Mancos shale formation below the east escarpment. Spring.

Potentilla gracilis Dougl. ex Hook. Cinquefoil
Prater Canyon, SN 171, EHB s. n.; Navajo Hill, MVEC 113. Locally common in the saddles along the North Rim. Summer.

Prunus armeniaca L. Apricot
Chapin Mesa, Headquarters, WEM 2089. The apricot has become established throughout the headquarters area. The trees bore fruit during the 1963 season and they will probably persist. There is a large apricot tree along the highway at the North Rim. An apple tree is growing along the trail to Spruce Tree House, but was not collected.

°*Prunus virginiana* L. Chokecherry
Navajo Canyon, SN 2082; Morfield Canyon, MVEC 13; Navajo Hill, MVEC 112; Bobcat Canyon, JAE 52; North Rim, B Cut, JAE 364; Chapin Mesa, north end, WW 1527. Locally common in mesic sites along the North Rim and in shaded side canyons to the south. Spring.

°*Purshia tridentata* (Pursh) DC. Bitterbrush
Chapin Mesa, Headquarters, SN 1573, WW 1547; without locality, MVEC 285; Bobcat Canyon, JAE 33. Common throughout the Mesa Verde, becoming very robust after fire. Spring.

Rosa nutkana Presl. ? Wild rose
North Rim, B Cut, WEM 2148. Occasional in moist sites. Spring.

Rosa woodsii Lindl.
Prater Canyon, SN 1709; Chapin Mesa, Fire Temple, SN 1747; Morfield Canyon, EHB 164; Spruce Tree Canyon, WEM 2176. Occasional; side canyons and North Rim. Summer.

RUBIACEAE — Madder Family

Galium aparine L. Bedstraw
Spruce Canyon, JAE 375, WEM 2069. Under oak thickets. Summer.

Galium coloradoense W. F. Wright Colorado bedstraw
Point Lookout, EHB s.n.; Balcony House, EHB 81a; North Rim, MVEC 72; Rock Springs, MVEC 151; Long House, JAE 61; Chapin Mesa, south rim, JAE 326; Mug House, WW 1554. Common on mesa rims and in canyons throughout the Mesa Verde. Spring.

SALICACEAE — Willow Family

Populus angustifolia James ex Long Narrowleaf poplar
Mancos River, C. W. Quaintance s.n. (Mesa Verde herbarium); North Rim, B Cut, WEM 2141. Rare in the Mesa Verde proper occasional along the Mancos River. Spring.

°*Populus fremontii* S. Wats. Fremont poplar
Mancos Canyon, C. W. Quaintance s. n.; Navajo Canyon, PRF 30; Rock Canyon, JAE 94. Scattered throughout the Mesa Verde, but not common. Spring.

°*Populus tremuloides* Michx. Aspen
Prater Canyon, EHB 298; Pine Canyon, WEM 2118. Rare; small stands occur throughout the Mesa Verde in moist, sheltered coves and box canyons. Spring.

°*Salix exigua* Nutt. Sandbar willow
Oak Tree House, EHB 225; ruin No. 12, JAE 100, WE 1615. Occasional along canyon bottoms and near seeps and springs. Spring.

Salix lasiandra Benth.
Bobcat Canyon, Double House, JAE 119; ruin No. 12, WE 1616; Chapin Mesa, Headquarters, WEM 2091. Habitat similar to *S. exigua*, but much less common. Spring.

Salix lutea Nutt.
North Rim, B Cut, WEM 2139. Locally common in moist sites. Spring.

SANTALACEAE — Sandalwood Family

Commandra umbellata (L.) Nutt. Bastard toadflax
Between Little Soda and Soda Canyons, SN 1579; Chapin Mesa, EHB 68; Far View Group, MVEC 50; Navajo Hill, MVEC 262; Wetherill Mesa, North Rim, JAE 5. Common in the pinyon-juniper forest and in the shrub zone throughout the northern part of Mesa Verde. Spring-summer.

SAXIFRAGACEAE — Saxifrage Family

°*Fendlera rupicola* A. Gray. Fendlerbush
Far View Group, SN 1575, PRF s.n., JAE 341, WW 1533; Cedar Tree Tower, MVEC 5; Navajo Hill, MVEC 61; Wetherill Mesa, North Rim, JAE 7. Common to locally abundant; primarily in the shrub zone, but also in canyons and on mesa rims. Spring.

Heuchera parvifolia Nutt. ex T. & G. Alumroot
Park Point, SN 1591; Cedar Tree Tower, MVEC 7; Navajo Canyon, JAE 350; North Rim, B Cut, WEM 2145. Somewhat rare; restricted to moist, shaded sites in canyons and along the North Rim. Summer.

Philadelphus microphyllus A. Gray. Mockorange
Spruce Canyon, SN 1743; Spruce Tree Canyon, SN 1765; North Rim, MVEC 75; Rock Springs, MVEC 126; Long House, JAE 57, SLW 1613; Wetherill Mesa, south end, WEM 2187. A common shrub, restricted to the mesa rims and cliff areas, especially in the southern end of the mesa. Summer.

Ribes aureum Pursh Golden currant
Lower Soda Canyon, EHB 54. Rare. Spring.

Ribes leptanthum A. Gray Gooseberry
Navajo Canyon, SN 1625, EHB 243; Cedar Tree Tower, MVEC 8; Prater Canyon, MVEC 80; Bobcat Canyon, JAE 51; Spruce Canyon, JAE 282. Locally abundant; drainages and side canyons, often in dense thickets. Spring.

Scrophulariaceae — Figwort Family

Castilleja chromosa A. Nels. Indian paintbrush
Park Point, SN 1594, JAE 334; Cliff Canyon, EHB 31; Navajo Canyon, MVEC 117; Wetherill Mesa, North Rim, JAE 128; Rock Canyon, JAE 200; Chapin Mesa, south end, JAE 270. Occurs throughout the Mesa Verde on mesa rims and in canyons, but common only in the openings of the shrub zone. Spring.

Castilleja linariaefolia Benth. ex DC.
Far View Group, SN 1669; Navajo Canyon, EHB 249, JAE 222; Moccasin Canyon, PRF s. n.; Rock Springs, MVEC 140; Rock Canyon, JAE 83, 91. Common in canyon drainages and along the North Rim. Summer.

Collinsia parviflora Dougl. Blue-eyed Mary
Wetherill Project laboratory, JAE 290; Chapin Mesa, Headquarters, WEM 2097. A small annual, occurring in moist shaded sites. Spring.

Cordylanthus wrightii A. Gray Birdbeak
Chapin Mesa, PRF 23; Bobcat drainage, JAE 184, An annual; common in moist years in bare areas of the pinyon-juniper forest. Summer.

Orthocarpus luteus Nutt. Yellow owlclover
Switchbacks Road, EHB 304c. Rare. Summer.

Orthocarpus purpureo-albus A. Gray
Purple owlclover
Morfield Canyon, EHB 268; Far View Group, MVEC 226; Bobcat drainage, JAE 186. An annual; abundant only in moist years in mesa-top big sagebrush stands and in the shrub zone. Summer.

Pedicularis centranthera A. Gray ex Torr.
Lousewort
Spruce Tree House, SN 1556; Long House, JAE 201; Wetherill Project laboratory, JAE 262. Common throughout the pinyon-juniper forest, but the leaves dying by autumn. Spring.

Penstemon angustifolius Nutt. ex Pursh ssp. *caudatus* (Heller) Keck
Wetherill Mesa, south end, JAE 215, WEM 2189. A blue-flowered plant, apparently restricted to the mesa rims in the southern part of the Mesa Verde. Spring.

Penstemon barbatus (Cav.) Roth ssp. *trichander* (A. Gray) Keck
Confluence of Navajo and Spruce Canyons, SN 1749; ruin No. 16, JAE 76; Chapin Mesa, Headquarters, WW 1559; Pool Canyon, WEM 2180. Occasional in canyons and on mesa rims; flowers red. Summer.

Penstemon barbatus (Cav.) Roth X *P. strictus* Benth. ex DC.
Chapin Mesa, Headquarters, WEM 2088. Rare; a single specimen noted. It has dark, pink-purple flowers, intermediate in color and shape between the species. Summer.

Penstemon bridgesii A. Gray
Chapin Mesa, Headquarters, SN 1787; Fewkes Canyon, EHB 227; ruin No. 12, JAE 98; Long House, SLW 1654. Common along mesa rims and on canyon ledges. Summer-autumn.

Penstemon comarrhenus A. Gray
Chapin Mesa, EHB 237; Chapin Mesa, Headquarters, SLW 2214. Rare; a blue-flowered penstemon of mid- and late-summer.

Penstemon eatonii A. Gray ssp. *undosus* (M. E. Jones) Keck
Spruce Canyon, SN 1656; Bobcat Canyon, JAE 31; Long House draw, JAE 53; Chapin Mesa, south rim, JAE 318. Common; mesa rims and canyon ledges; red-flowered. Spring.

Penstemon jamesii Benth. ssp. *ophianthus* (Pennell) Keck
Mancos Canyon, SLW 1762, WEM 2174. Apparently restricted to high gravel terraces in Mancos Canyon. Spring-summer.

Penstemon linarioides A. Gray ssp. *coloradoensis* (A. Nels.) Keck
Chapin Mesa, Headquarters, SN 1557, 1701; Soda Canyon Tipoff, MVEC 48; Rock Springs, MVEC 138; confluence of Long and Bobcat Canyons, JAE 36; Long House, JAE 60. Widespread throughout the Mesa Verde, primarily in the pinyon-juniper forest; blue-flowered. Spring-summer.

Penstemon strictus Benth. ex DC.
Wetherill Mesa, North Rim, JAE 129, 155, 389, WEM 2196. The common blue-flowered penstemon of the North Rim shrub zone. Summer.

Penstemon strictus ssp. *strictiformis* (Rydb.) Keck
Soda Canyon Tipoff, MVEC 47; ruin No. 16 draw, JAE 69; Long House, JAE 180; Pine Canyon, JAE 369; Chapin Mesa, Headquarters, WW 1546. The common blue-flowered penstemon in the mesa-top pinyon-juniper forest. Spring-summer.

Verbascum thapus L. Mullein
Chapin Mesa, Headquarters, WEM 2095. Disturbed sites and waste places; introduced from the Old World. Summer.

Veronica anagallis-aquatica L.
Chapin Mesa, Headquarters, WEM 2103. Moist places, locally common. Summer.

SOLANACEAE — Potato Family

Lycium pallidum Miers Tomatilla
Far View Group, SN 1677, SLW 1857; Navajo Canyon, JAE 219, SLW 1750. Rare; occurring on floodplain in Navajo Canyon and on trash slopes of prehistoric sites. Spring-summer.

°*Nicotiana attenuata* Torr. ex S. Wats. Wild tobacco
Chapin Mesa, ruins road, JAE 233, SLW 1847. A weed in waste places; known only from the location cited. Summer-autumn.

Physalis fendleri A. Gray Ground cherry
Rock Canyon, WE 1621; Mancos Canyon, WEM 2154. Rare; a plant of disturbed soils. Summer.

Solanum jamesii Torr. Wild potato
Confluence of Spruce and Navajo Canyons, WAW 5627. Rare.

Solanum triflorum Nutt. Nightshade
Morfield canyon, EHB 208; Far View Group, SLW 1854. A plant of disturbed soils; rare. Summer.

TAMARICACEAE — Tamarix Family

Tamarix pentandra Pallas Salt cedar
Soda Canyon Tipoff, MVEC 24; Rock Canyon, JAE 105. Restricted to intermittant stream channels in canyons, and to springs and seeps. An Old World adventive (Christensen, 1962). Summer-autumn.

TYPHACEAE — Cattail Family

°*Typha latifolia* L. Cattail
Chapin Mesa, Headquarters, WAW 5227; Rock Canyon, JAE 175, WE 1619. Restricted to seeps and springs throughout the Mesa Verde. Summer.

UMBELLIFERAE — Carrot Family

Aletes macdougalii Coult. & Rose
Long House, JAE 2; Rock Canyon, ruin No. 12, JAE 195. Common; slopes of side canyons. Summer.

Cympterus bulbosus A. Nels
Lower Soda Canyon, EHB 48; Wetherill Mesa, North Rim, JAE 194; Chapin Mesa, JAE 250; Park Point, JAE 251; Jackson Butte, west escarpment, JAE 277. Occasional in successional mesa-top stands. One of the earliest plants to flower in the spring.

Cymopterus purpurascens (A. Gray) M. E. Jones
Rock Canyon, ruin No. 12, JAE 205. Canyon slopes. Spring.

Cymopterus purpureus S. Wats.
Chapin Mesa, south rim, JAE 320. Rare. Spring.

Ligusticum porteri Coult. & Rose Lovage
Between Little Soda and Soda Canyons, SN 1580; Navajo Canyon, S 1667; Prater Canyon, SN 1714; North Rim, EHB 65; Navajo Hill, MVEC 67; Spruce Tree Canyon, WEM 2074. Locally common; moist shaded canyon bottoms and along the North Rim. Summer.

Lomatium grayi Coult. & Rose. Biscuitroot
Between Little Soda and Soda Canyons, SN 1578; North Rim, EHB 36; Point Lookout, MVEC 68; Rock Springs, MVEC 130; Weth-

erill Mesa, North Rim, JAE 204; Park Point, JAE 286, 337. Common in openings along the North Rim. Spring.

Lomatium triternatum (Pursh) Coult. & Rose ssp. *platycarpum* (Torr.) Cronq.
Park Point, SN 1583; Navajo Hill, MVEC 66; Far View Group, JAE 303; Wetherill Mesa, WEM 2195. Occasional; shrub zone. Spring.

Verbenaceae — Vervain Family

Verbena bracteata Lag. & Rodr. Vervain
Morfield Canyon, EHB 287; Wetherill Project laboratory, JAE 228. An adventive; common along roadsides and other waste places. summer.

Violaceae — Violet Family

Viola sp.
Prater Canyon, SN 1720. The specimen is vegetative and the diagnostic characters are missing. Evidently rare. Spring.

Vitaceae — Grape Family

Parthenocissus vitacea (Knerr) Hitchc.
Virginia creeper
Cliff Palace, EHB 221; Pine Canyon, WEM 2127. Rare; moist shaded canyons. Spring.

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ANDREW H. BARNUM

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FOREWORD

This is another of a series of major publications on desert ecology resulting from studies at the Nevada Test Site by the Brigham Young University Department of Zoology and Entomology in cooperation with the United States Atomic Energy Commission. Although some of the studies are the result of independent investigations by specialists who are not on our departmental staff, they are part of the major project initiated cooperatively by B.Y.U. and the A.E.C. to determine the effect of nuclear detonations on the native animals of the Nevada Test Site.

Dorald M. Allred and
D Elden Beck
Project Supervisors

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ORTHOPTERA OF THE NEVADA TEST SITE

by

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Research Associate

INTRODUCTION

This study is part of a larger ecological project to comparatively analyze the native animals at the Nevada Test Site. The objectives of this study were to (1) classify the species and provide taxonomic keys for their differentiation, (2) evaluate the populations, and (3) determine the seasonal and geographical distributions of native Orthoptera in areas disturbed by atomic explosions as compared to those in undisturbed areas, both contiguous and distant.

The area encompassed by the Nevada Test Site and covered by this report lies principally in the southeastern part of Nye County and approximating both Clark and Lincoln counties.

The overall study was begun in 1959 and continued into late 1963 with the periodic sampling of Orthoptera from some areas of the test site. The use of special sunken can traps instrumented the collecting of ground-inhabiting species. These traps were established in transects or quadrates according to standardized techniques. In addition, thorough collecting was done at intervals by field personnel.

The author began organized collecting at the test site as soon as the weather permitted in the spring of 1961. Periodic trips extended through March, April, and May. Extensive collecting was done nearly every day throughout the months of June, July, and August, when these insects were most active. Periodic collecting was again resorted to through September, October, and November, until cold weather did not justify a return to the test site. Other collecting was done, as indicated, by field personnel instructed in the techniques of collecting during all months of the years that the study was in progress.

Primary emphasis was directed toward a complete systematic and ecological study of those ground-dwelling animals which may be selected as indicator animals because of their distribution and abundance in many plant communities throughout the test site.

Analysis of data was facilitated by an IBM punch card system. Field data were recorded on special forms and were transferred to IBM punch cards. The Brigham Young University Computer Research Center analyzed the project results with an IBM 650 Computer.

HISTORICAL REVIEW

The taxonomy and distribution of the American Orthoptera are actually well known in comparison with other insect orders. The Orthoptera of the Western United States, however, are still imperfectly known. The actual collecting of Nevada Orthoptera began in the early history of entomology when workers of the geological and geographical surveys entered the territory and made limited collections of the more conspicuous species. Of primary interest to these collections and the subsequent publication of the information were Cyrus Thomas and Lawrence Bruner. Although he was never in the state, Samuel H. Scudder did more for the systematic treatment of Orthoptera than any other individual in the nineteenth century. He not only named many new species, but revised many of the recognized groups into a uniform order.

The first quarter of the present century was dominated by James A. G. Rehn and Morgan Hebard, both representing the Philadelphia Academy of Sciences. On a number of occasions they entered the state and collected intensively, particularly in the southern sections, as well as collecting extensively throughout southwestern United States. Not only did they build up a large collection of Orthoptera from the southwest, which included a number of new species

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from southern Nevada, but they have also been instrumental in doing most of the recent systematic work.

Primarily on the basis of what had already transpired Dr. Ira La Rivers of the University of Nevada entered into a study of the Nevada Orthoptera, which resulted in "A Synopsis of Nevada Orthoptera" in which he contributed considerable original information on the ecology of the Nevada Orthoptera but little on the systematics of the group.

Contrary to the extensive work that has been done in systematics, there have been relatively few competent studies made of the ecology, the life histories and habits of North American Orthoptera. The earlier works in ecology, such as made by Vestal (1913), Hubbell (1922), Strohecker (1937), Isely (1937, 1938), and Urquhart (1941), were important and served as a basis for the more complete works of Cantrall (1943) and Tinkham (1948). All of these important papers, however, contributed little to the knowledge of the Nevada Orthoptera because they covered areas far distant from the present study site, and very few species overlap into this area. The author is grateful to these individuals for providing a basis upon which the present study is made.

Other recent workers have attempted to study the ecology of some groups of Orthoptera by controlled laboratory experiments, but the ecological behavior of any species differs within its own range, and is far different from any so-called "controlled" laboratory situation. Nothing of a laboratory nature could be substituted for adequate field studies. The present report contains field observations and studies of all of the species here recorded.

ACKNOWLEDGMENTS

Any scientific study represents the combined efforts of many individuals and groups who have contributed to the success of the study. Appreciation is therefore extended to those individuals for the assistance rendered.

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The following personnel contributed greatly by collecting specimens, accompanying the author in the field, and contributing to the effectiveness of collecting: Clive Jorgensen, field director; D. Elmer Johnson and Merlin Killpack, consultants and specialists; Carl Ingersoll, Morris Goates, and Gerald Richards, field biologists; and especially for the long hours of collecting with and driving for the author, field biologists Willis A. Packham, Arthur Anderson, and Arnold Orton.

The author is further indebted to Dr. Ashley B. Gurney of the U. S. National Museum for verifying and classifying certain species of Orthoptera; and Dr. Arthur C. Cole, project consultant and specialist, for the determination of several species of ants.

Appreciation is extended to those other individuals who contributed in any way to the completion of the present research.

METHODS OF STUDY

When the author began an on-site investigation of the Orthoptera of the Nevada Test Site in 1961, certain quadrate and transect studies had already been established. A reconnaissance of the test site was made to determine the most ideal habitats for Orthoptera and to check additional areas that might be sampled. Special sunken can traps (Allred, *et al.*, 1963) were established at regular intervals around the periphery of quadrates and along line transects. The cans were emptied regularly three times per week in all areas, and the invertebrates collected were placed in 70% alcohol. Major sampling areas were run continuously over a one-year period so that a total seasonal sampling could be achieved. All the Orthoptera thus collected have been submitted to the author for study and identification.

Special berlese and host-plant studies were undertaken periodically and systematically, but

the Orthoptera collected were of minor significance to the overall study.

Several of the field biologists carried collecting nets and kept accurate information on the specimens captured.

To effect a systematic study, the author visited current study plots on every trip to the test site during the spring and autumn, and during the summer visited study plots at least twice a week, generally three times a week. Because of the many miles between some study plots this systematic collecting occupied at least half the time; the remainder of the time was spent in collecting from special areas, in between or adjacent to the study plots, and in night observations and collecting. Because of the extensive area, some study plots were visited only once by the author during the entire season.

The collecting method most generally employed, in addition to the special can traps, was use of a sweeping net on shrubbery and other vegetation, and an aerial net to capture the great majority of specimens, as most of the orthopteran inhabitants of the southwest deserts are strong fliers. A great deal of difficulty was encountered in sweeping desert plants because of their spinose nature. When these plants were sampled, an observation was first undertaken. The entire shrub or plant was carefully examined and notes taken on any orthopteran present. Periodically an entire shrub was torn apart to reveal the presence of specimens. Many insects not visible because of their concealing coloration and patterns were thus captured.

During the hot summer months many of the desert shrubs lose their leaves. The most thorough, accurate, and speedy collection from these shrubs was by trampling. Each shrub was trampled systematically, spirally from the outside to the inside. It is believed that very few orthopterans escaped when such methods were employed. An aerial net was used to capture those specimens trying to escape.

Many of the data recorded are sight records. If all the observed specimens had been captured there would have been insufficient time to examine all the areas.

No special sweeping data were maintained with reference to length of stroke, distance from the ground, speed, etc. Most species of the desert are so different that sweeping methods must be adjusted to the habits of the various forms to achieve maximum effectiveness.

The height at which some species occur on vegetation is variable according to atmospheric conditions. During the hottest hours of the summer day many species are found characteristically at the tips of branches of shrubs, others near the ground in the shade, and some on the ground underneath the vegetation. Very few specimens can be found on the ground in full sun during the hot summer hours.

Desert vegetation is typically that of scattered plants, and it is possible to check an area in a short time by rapid walking between plants to observe or capture the strong flyers, and by systematic visual or mechanical examination of the plants.

Night collecting was chiefly visual with flashlights or lanterns and the use of aerial nets to capture specimens. No systematic night light collecting was maintained, although some sampling was done with black (ultra violet) light.

Baits of rolled oats and/or molasses in can traps or scattered upon the ground were tried in some areas. No special advantage could be determined, however, inasmuch as the cans frequently contained mice and other rodents or other predaceous animals. As a matter of fact, as evidenced by parts of bodies, many ground-dwelling specimens captured in the traps were consumed by these animals, notably grasshopper mice (*Onychomys*) and less frequently by shrews (*Sorex*). Wherever these rodents occurred in the cans, few or no arthropods were present. Some lizards and predaceous arthropods, especially tenebrionid beetles and scorpions, were responsible for the destruction of large numbers of specimens.

Notes were made, wherever possible, on the songs of the various species, both by day and night, though this is a minor contribution of the overall study because of the seemingly inactive nature of so many of the desert species and the absence from the test site of many stridulating nocturnal forms.

More than 8,000 specimens, both nymphs and adults, were collected and preserved in the course of the investigation. As noted earlier, specimens collected from the can traps were placed directly into separate vials of 70% alcohol. Some of the specimens of the most common species were captured, examined, and later released in the same area.

Frequency and Abundance

No statistical frequency and abundance (i.e., numbers of specimens per sweep) was attempted because of the general scarcity of orthopteran forms at the test site. Some visual observations on abundance were made.

It must be emphasized that the present discussion is relative to the Orthoptera of the Nevada Test Site only during the years when the

study was in progress. The same species or comparative numbers of specimens may not be present in any other year, before or after the testing program was begun. Cyclic appearance of certain species must be taken into consideration, and the same species that were numerous during the recorded period may actually be less numerous than some other species at some other time.

Nearly all grasshoppers fluctuate in numbers from year to year. One year they may be very numerous, whereas the next year few will appear. Such insects occur in small numbers for a year or two, gradually increase, and when a favorable season occurs appear in enormous numbers and may cause great damage, only to disappear again for several years.

The reason for this fluctuation is apparent. While grasshoppers are capable of increasing twenty to sixty times in one year, their enemies and diseases are capable of increasing several hundred and up to thousands of times in one season. While the grasshoppers are scarce, their parasites have a difficult time to find the hosts, and, as a result, the majority of the parasites perish. Then, as the grasshoppers increase in numbers, the few parasites left have no trouble in finding them and they, too, increase enormously. The year the grasshoppers are most numerous is often the year in which the parasites increase to such an extent that practically no grasshoppers or eggs are left to produce a brood the following year. But they are not present in sufficient numbers to cope with the swarms of grasshoppers in the year in which they are most needed.

The weather plays an important part in fluctuation of numbers. Cold, wet weather in the spring will destroy a large number of young grasshoppers. Hot, dry weather allows all eggs to hatch and the young insects to thrive. The same hot dry weather burns up the vegetation so that there is less for them to feed on. Drought and grasshoppers often go together, especially if the drought extends through several years.

In some test site areas visited regularly a large population of robber flies, bee flies, lizards and other predaceous animals were present that might have accounted for the scarcity of specimens. In the author's experience of collecting in desert environments, the specimens were far too few at the Nevada Test Site while the study was in progress.

Whenever a species was discovered in any area, as large a series as possible was collected to show variations. Too many morphologists and taxonomists fail to realize the importance of a series and submit descriptions and drawings on only one specimen without recognizing variation within the group. Many new species have been described from unique types, and in many instances this has resulted in a long list of confusing synonyms.

Study of Individual Species

Each species represented by a series of specimens was studied for variability, and notes and measurements in millimeters were made of representative specimens of both sexes. Measurements were made with a standard micrometer in a binocular microscope. The length of the body and tegmen on large specimens was determined by metric callipers.

The most accurate species analysis should be made upon consideration of all measurements given, rather than relying on a single measurement, such as total body length, as has been used in the past. Accordingly, the following measurements were made on the series of specimens.

Length of body. The measurement was made from vertex to tip of ovipositor of female or subgenital plate of male, but excluding tegmina and wings that extend beyond the tip of the abdomen. Although this is one of the standard measurements made on Orthoptera it is variable and actually less valuable than some other measurements. The female that has been ovipositing or copulating often has the abdomen abnormally stretched; in some cases the abdomen is abnormally retracted. In the male, especially in some groups such as *Aeoloplides*, the abdomen is consistently upturned, and measurements are unreliable. In such cases the measurements are given to the most posterior part of the abdomen.

Greatest depth of body. This measurement was not used consistently. The greatest body depth in nearly all species was measured from the mesosternum to the median carina of the pronotum.

Length of pronotum. The pronotal length was taken in most cases, although it varied because of caudal prolongation. In some specimens the pronotum was noticeably aberrent, probably due to developmental injury or malformation.

Greatest breadth of pronotum. The greatest pronotal breadth occurs in most species on the disk of the metazona.

Depth of pronotum. The measurement is of importance to some groups with a high median pronotal carina, and to others with modified lateral pronotal lobes. The measurement

was from the ventral edge of the lateral lobe to the highest dorsal part, usually the median carina.

Length of tegmen. The tegminal length is considerably variable in some groups. The measurement was made of the wing in resting position from the angle of the radius, media, and costal veins in the area of the pronotum to the tip of the tegmen. In some cases where the pronotum is greatly prolonged the measurement is given as projecting beyond the pronotum. This is individually stated in the account of the species. No measurements were made on the total length of the wing, but in some species a measurement is given for wings projecting beyond the tegmina. In nearly all species examined the tegmina and wings are subequal in length.

Length of caudal femur. Measurements on the caudal femora have not been consistently reported, but may be important to Orthoptera systematics. This structure shows less variability than other body structures. The length was measured from the anterior development to the greatest prolongation of the genicular lobe.

Greatest breadth of caudal femur. This measurement, with the length, shows the saltatorial ability of the insect.

Other miscellaneous measurements were made according to the species and are included in the account of the individual species.

DESCRIPTION OF THE AREA

Location

The Nevada Test Site is located in Nye County, Nevada, contiguous to both Lincoln and Clark counties. It is approximately 65 miles northwest of Las Vegas, Clark County, Nevada, just off U. S. Highway 95. The test site encompasses some 1000 square miles, being an area approximately 40 miles from north to south by approximately 25 miles from east to west. The present study is limited by these boundaries. Most of the collecting was restricted to areas immediately surrounding the numerous access roads within the area.

Physiography

The obvious features of the Nevada Test Site are the two playa lakes, Frenchman and Yucca, and the very gradual sloping flats surrounding these areas. Scattered throughout and actually isolating these areas is a series of mountains, especially prominent to the northwest. The land is typically desert and very arid, having a total precipitation of approximately five inches per year, this occurring largely in July and December, with the most arid months being October and May. The soil is very poor and highly alkaline, especially around the playas where there is an associated, hazardous desert pavement, the small pebbles scattered over the surface of the earth. Immediately below the surface is a very dusty, powdery soil. These areas extend to the bajadas and the mostly barren foothills and higher elevations, variously covered with pinyon and juniper.

The only permanent water is restricted to few areas. Cane Springs, west of Frenchman Playa, has a small empounded water area of approximately two hundred square feet. The water at Tippipah Spring, northwest of Yucca Playa, is restricted to the inside of a tunnel, but provides water for some animals that venture into the shaded interior. White Rock Valley, north of Tippipah Spring, has a tiny amount of water from one spring. In addition there are some few areas to the northwest with minute amounts of permanent water, and a few wells have been built for industrial purposes. Such an environment is not conducive to some orthopterans, but is more typical of the habitat of the strong flying grasshoppers.

Vegetation

Much of the Nevada Test Site is typical of the Lower Sonoran Life Zone. The southern part is typically Mohave Desert with its *Larrea-Franseria* vegetation. More typical Upper Sonoran conditions are found in the northern section and around the bajadas adjacent to the northern limits of the Mohave Desert. The third faunal zone represented at the test site is the Transitional of higher elevations. Some higher valleys are typical of the Great Basin Desert with its associated *Artemisia*.

Immediately surrounding the completely barren Frenchman Playa of compacted silts and clays is a fringe area of *Lycium pallidum*, the dominant plant, with some *Grayia spinosa, Lycium andersonii, Dalea polyadenia, Eurotia lanata,* and other plants. This fringe area of *Lycium* is bordered by a much larger, very extensive area of almost pure *Larrea divaricata* with its associated *Franseria dumosa, Hymeno-*

clea fasciculata, *Grayia spinosa*, *Lycium andersonii*, *Ephedra nevadensis*, and *Dalea polyadenia*. The *Larrea-Franseria* vegetation is continuous upon the bajadas to the very steep and sharp hills and ridges with their scattered grasses and other vegetational types.

Separating Frenchman and Yucca playas is a series of hills and ridges with some growths of *Coleogyne ramosissima* and *Yucca brevifolia*. Immediately to the north of Yucca Playa is an association of *Atriplex confertifolia* and *Kochia americana* with some *Eurotia lanata* and *Artemisia spinescens* designated as *Atriplex-Kochia*. The next belt of vegetation, very extensive to the north and east, less extensive to the west and represented by a small fringe to the south between the playa and the steep hills, is a belt of *Grayia-Lycium*. The two dominant species, *Grayia spinosa* and *Lycium andersonii*, are associated with some *Eurotia lanata*, *Atriplex canescens*, *Oryzopsis hymenoides*, *Artemisia spinescens*, *Stipa speciosa*, and other plants variously scattered throughout the entire belt. Through the *Grayia-Lycium*, at various ground zero locations where atomic detonations have occurred, are extensive areas of *Salsola kali*, the first plant to appear in a new succession.

To the northwest and northeast of the *Grayia-Lycium* belt is a well-developed community of *Coleogyne*, which is the dominant flora surrounding Yucca Flat and extending to the various mountain ranges. The flora of the canyon approaches to the higher mesas to the north and west is transitional. Oak, *Quercus gambelli*, and bitterbrush, *Purshia glandulosa*, are common, along with *Chrysothamnus viscidiflorus*, *Eriogonum fasciculatum*, and other plants. The long valley approaches to the mesas are covered with *Artemisia tridentata*, with its associated grasses, particularly *Oryzopsis hymenoides*, replacing the more typical *Coleogyne*.

Some small stationary sand dunes with a mixed vegetation of *Purshia glandulosa* and many ephemerals and other annuals along with herbaceous and woody plants are found in the vicinity of the mesas.

Pinus edulis and *Juniperus osteosperma* are found on the higher mesas. Scattered among the pinyon-juniper are groups of *Purshia glandulosa*, *Quercus gambelli*, *Artemisia tridentata*, and other shrubs.

Jackass Flats, in the southwest corner of the test site, consists of *Larrea-Franseria*. The approach to this large area consists of mixed vegetation typical of the bajada.

These biotic communities, shown by the inserted map, have been detailed by Allred, Beck, and Jorgensen (1963).

Regular Collecting Areas

The following collecting areas were visited regularly twice to three times per week during the months of June, July, and August, and twice a month during March, April, May, September, October, and November, as outlined in the "Methods of Study" above. The type of collecting was modified to suit each particular area according to the vegetation present.

Area 1. (Yucca Flat, northwest of Yucca Playa) Some of the most intensive collecting was done in Study 1B, a radiating transect of eight lines running symmetrically from ground zero, the point directly under the point of detonation. The lines were marked 1BA, 1BB, 1BC, etc., through 1BH. Thirty stations were located along lines B, D, F, and H, each station being 264 feet apart. A total of 24 can traps were open continuously from March 9 to September 28, 1961; and from October 9, 1961, to February 15, 1962; and April 3 to May 18, 1962. These same stations were open for three days in the first and third week of each month.

All plants from ground zero to a radius of approximately one mile have been visibly affected by the explosions, the damage being less severe progressing from ground zero to the ends of each transect. In the immediate area where the plants were completely destroyed there has been an early plant succession of Russian thistle, *Salsola kali*. Near the maximum radius of total plant destruction a ground cover of a white composite, *Chaenactis* sp., is evident, especially during the spring. From this point outward the normal perennial vegetation is making a come-back. At the extreme periphery of this star transect there has ben no visible damage, at least to the smaller perennial plants.

In addition to the regular collecting from the can traps, a concerted effort was made to collect along the 1BF transect, this transect having been chosen as typical of the area. The collecting time spent in the 1B area varied from one to several hours, and from time to time occupied different hours of the day and night.

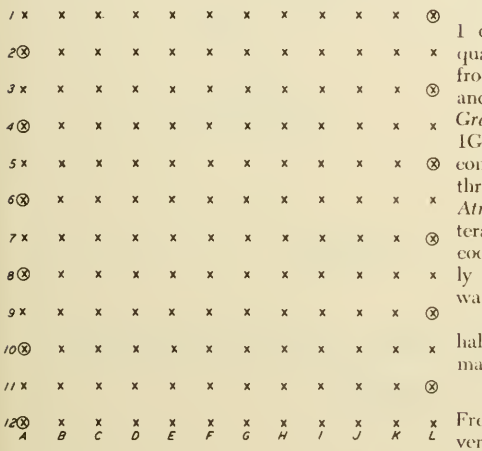
The only orthopterans collected in the first fifteen stations from ground zero outward in the belt of *Salsola* were an occasional *Xanthippus corallipes* early in the spring, and *Trimerotropis pallidipennis* and *T. strenua* during much of the summer. The ground-inhabiting *Achcta assimilis*, three species of *Ceuthophilus*, and *Stenopelmatus fuscus* were collected in can traps.

Study 1F was established as a quadrate in a *Salsola* habitat near ground zero. Collecting cans were arranged 75 feet apart according to Diagram 1. This same plan was carried throughout the major quadrate studies.

See Table 1 for a complete summary of specimens collected in Study 1F and the *Salsola* belt of Study 1B.

Most of the collecting in Study 1B was done around stations 19 through 23, a variable belt of *Salsola*, *Oryzopsis hymenoides*, *Hymenoclea fasciculata*, *Stipa speciosa*, *Chrysothamnus viscidiflorus*, *Ephedra nevadensis*, and *Lycium andersonii*. Beyond station 23 were various concentrations of *Haplopappus cooperi*, *Grayia spinosa*, *Eurotia lanata*, and near the end of the transect, *Artemisia tridentata*, *Coleogyne ramosissima*, *Hymenoclea fasciculata*, and *Artemisia spinescens*.

Study 1G, though primarily set up as a reptile study through *Grayia-Lycium*, consisted of a quadrate of one hundred can traps marked from one through ten and from A through J, each set at a distance of 35 feet. Although these regularly produced large numbers of ground-dwelling Orthoptera, the specimens were only occasionally preserved. The area was regularly swept for Orthoptera and produced a variety of species from time to time.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12⊗ x x x x x x x x x x x
A B C D E F G H I J K L

Diagram 1. Typical quadrate showing position of can traps(o).

Area 4. (Immediately to the north of Area 1 described above) Study 4A consisted of a quadrate of twelve can traps open continuously from September 22, 1960, to September 23, 1961, and from October 10-12, 1961. This is a typical *Grayia-Lycium* habitat similar to study 1B or 1G, but with larger shrubs. Desert pavement is common on the surface. A small sandy wash through most of the study is lined primarily with *Atriplex canescens*, host to a variety of Orthoptera during the hot mid-day hours. During the cooler parts of the day the insects were commonly found along the gravel in the bottom of the wash.

Specimens collected in the *Grayia-Lycium* habitat of study areas 1B, 1G, and 4A are summarized in Table 2.

Area 5. (Frenchman Flat, southwest of Frenchman Playa) This area consisted of three very extensively collected studies, two quadrates and one line transect, each established with can traps for the capture of ground-dwelling

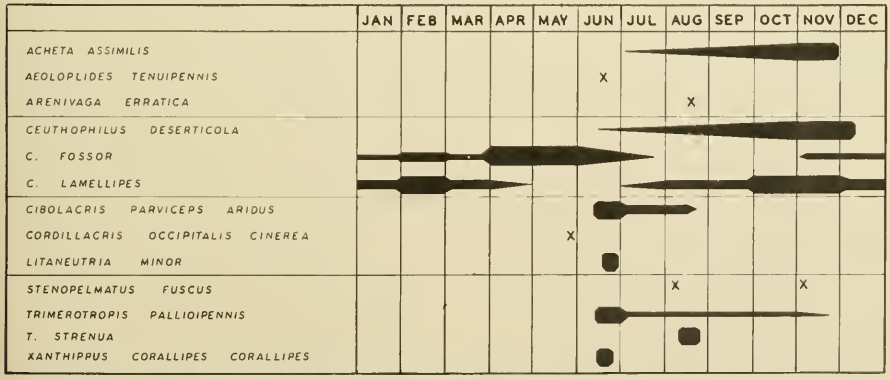


Table 1. Seasonal distribution of the Orthoptera characteristic of the *Salsola* habitat (Study 1F).

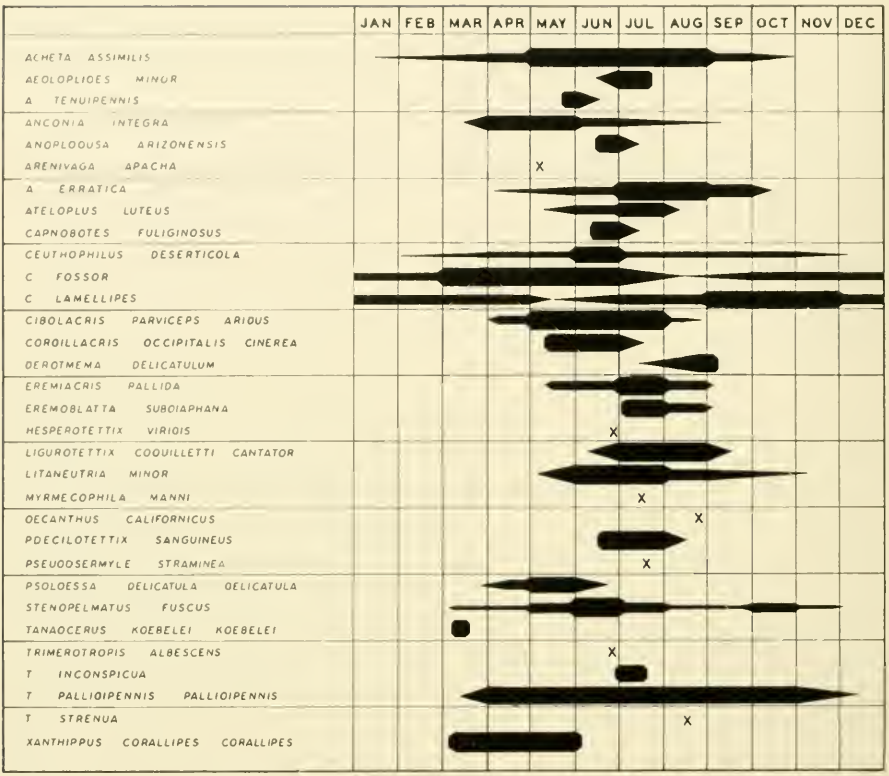


Table 2. Seasonal distribution of the Orthoptera characteristic of the *Grayia-Lycium* habitat (Studies 1B, 1G, 4A, 5E).

arthropods. Study 5A was operated continuously from September 22, 1960, to September 22, 1961, in a *Larrea-Franseria* habitat. The vegetation consisted more specifically of *Larrea divaricata, Franseria dumosa, Hymenoclea fasciculata, Grayia spinosa, Lycium andersonii, Ephedra nevadensis,* and *Dalea polyadenia.* The surface was desert pavement, particularly typical of the Frenchman Flat area. A few slight depressions and washes were present in the quadrate.

Study 5CQ was situated immediately across the road and north of Study 5A, and consisted of the same type of vegetation. Both areas were usually collected together. Study 5CQ consisted of a line transect of 25 can traps set 35 feet apart. The area was originally designated for a special study, but the cans were occasionally checked for ground-dwelling Orthoptera when the area was not being utilized for its specific purpose. These cans were open from June 24-30, 1961; from July 10 to August 4, 1961; and from August 8-20, 1961.

Between studies 5A and 5CQ is an asphalt road. On both shoulders of the road the *Larrea* was very high, luxuriant and green. Most of the two common *Larrea*-inhabiting species, *Bootettix punctatus* and *Insara covilleae,* were collected in these dense shrubs near the road. These specimens were all very brightly colored. Beyond the shoulders of the road the shrubs were smaller, less dense, and more generally brownish in color. The specimens collected in these shrubs were fewer in number, and the same two species of grasshopper were brown rather than green.

Orthopterans collected in the *Larrea-Franseria* areas are summarized in Table 3.

Study 5E, another quadrate, was predominantly *Lycium pallidum.* Situated nearer French-

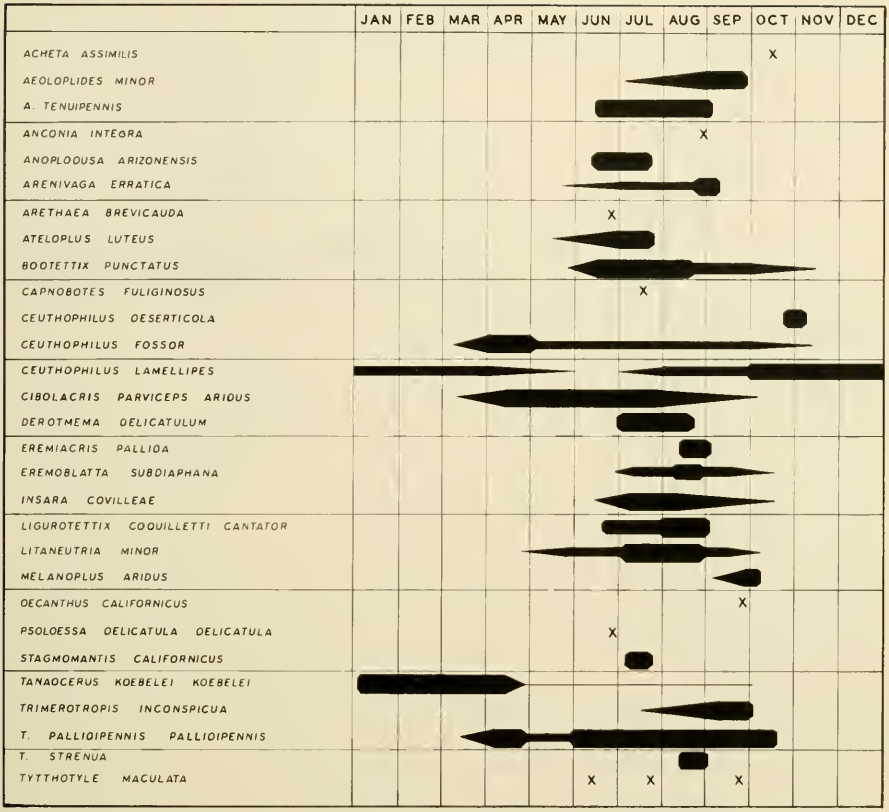


Table 3. Seasonal distribution of the Orthoptera characteristic of the *Larrea-Franseria* habitat (Studies 5A, 5CQ).

man Playa, the average elevation of this study was only slightly lower than studies 5A and 5CQ and was considerably more alkaline. A nearby outwash leading to Frenchman Playa was very alkaline with an abundance of *Atriplex canescens* and *A. confertifolia*. The alkali grasshopper, *Anconia integra*, was most common to this latter area. The can traps in this study were open from September 22, 1960, to September 22, 1961.

Area 6. (Yucca Flat, adjacent to the northern edge of Yucca Playa) Study 6A was a typical quadrate located in an *Atriplex-Kochia* habitat. The vegetation consisted of *A. confertifolia* and *K. americana*, with some *Eurotia lanata* and *Artemisia spinescens*. The vegetation was scattered, with large areas of alkali-encrusted surface. During most of the season the vegetation was green only in the immediate confines of the roads and along some of the lower depressions. In other areas it was very dry and brittle. The can traps in this study area were open continuously from September 22, 1960, to September 23, 1961. Table 4 summarizes the Orthoptera collected in this *Atriplex-Kochia* habitat.

Area 10. (Bajada, north of Yucca Playa) This typical quadrate, known as study 10D, was situated in a *Coleogyne* habitat. The rolling terrain, drained by a sandy wash with numerous large rocks, sloped between the ridges and Yucca Flat. The study was situated near an extensive area of active radiation, the debris being collected in long windrows. Whether or not any of the Orthoptera collected in the area had come in direct contact with this radiation is unknown.

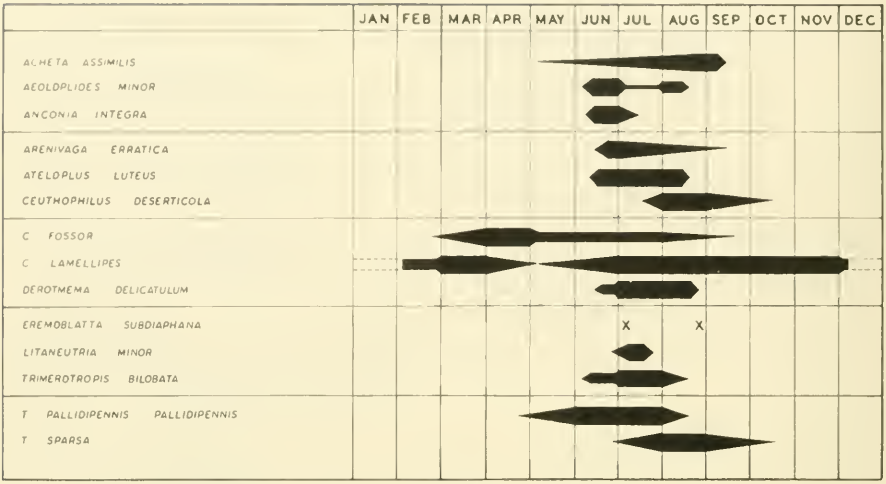


Table 4. Seasonal distribution of the Orthoptera characteristic of the *Atriplex-Kochia* habitat (Study 6A).

No grasshopper migrations were observed at the Nevada Test Site, and direct body contact with this debris is questionable. Dates of operation of can traps were from September 22, 1960, to September 23, 1961, and from October 10-12, 1961.

Coleogyne is a poor environment for Orthoptera. Some other vegetation, typical of the bajada, was present. Table 5 summarizes the specimens collected in this *Coleogyne* environment.

Area 12. (Particularly Rainier Mesa, northwest of Yucca Flat) A typical pinyon-juniper association is found on Rainier Mesa. Two comparative studies were established. Study 12A was situated in a disturbed area near the detonation of a nuclear explosion. Most of the trees were killed off by the physical effects of the explosion. The dominant vegetation consisted of small oaks, *Quercus gambelli*, and bitterbrush, *Purshia glandulosa*. The surface rocks had been disturbed, and a series of large fissures in the ground from the rim of the mesa outward was evidence of the explosion.

The other study, 12E, was in an undisturbed pinyon-juniper area of living trees and no rock disturbance or ground fissures.

Ten cans were open in study 12A, fifteen cans in study 12E, from July 24-28, 1961, and from August 11-19, 1961. Then, ten cans were open in each study from October 19 to November 17, 1961, and from April 10-12, 1962.

The can traps in both studies were established to test the effectiveness of natural cover (flat rocks) as opposed to the artificial cover (masonite boards) generally used with the cans, or no cover; and to test the effectiveness of bait as opposed to no bait. One of the best ways to capture ground-dwelling Orthoptera, particularly camel crickets, is by the use of rolled oats or molasses. (Although no molasses was used in these areas it was tested in study 5CQ in a controlled bait experiment. The study was carried out for all animals, especially arthropods, and the data on the Orthoptera were recorded along with the other captures. The baits were changed from time to time during the course of the experiment and consisted of banana oil, stale beer and brown sugar, molasses, molasses diluted with diesel fuel, rolled oats, and meat of various kinds.) Eight of the cans were covered with flat rock covers elevated sufficiently to permit any animal to crawl under for protection; twelve of the cans were covered with the masonite boards; and five cans were left without covers. In some of the cans oatmeal was placed only in the cans, some were left without bait, and the remainder had bait scattered about the ground as well as in the can. The baiting practice was abandoned after the second visit to the areas because there was no significant difference in the results and many of the arthropod inhabitants as well as the bait had been eaten by vertebrate predators.

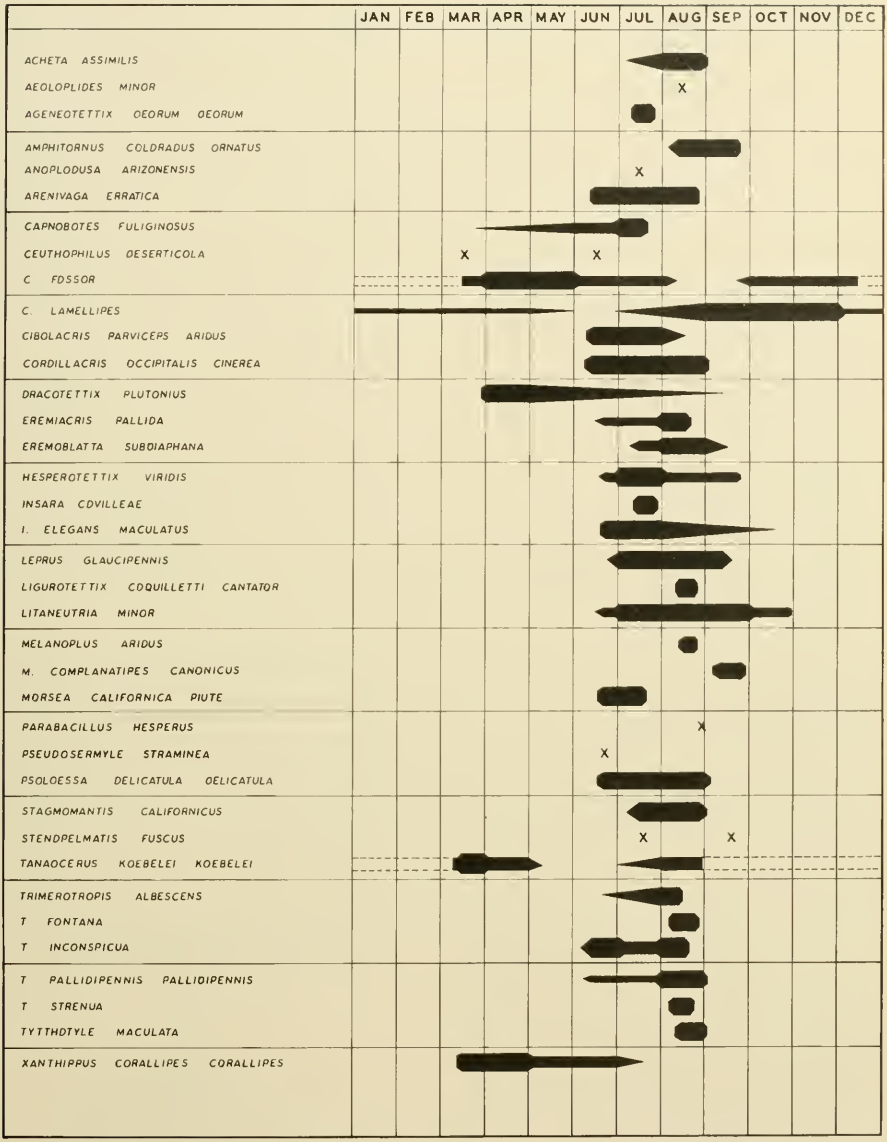


Table 5. Seasonal distribution of the Orthoptera characteristic of the *Coleogyne* habitat (Studies 10D, TA).

Most of the Orthoptera were collected from the disturbed area, study 12A. This area also contained more succulent annuals and biennials and smaller perennials, thus providing a more suitable food supply for some species.

The most numerous collections in these areas were of camel crickets—two species of *Ceuthophilus* and *Pristoceuthophilus*—as well as *Stenopelmatus* and the ant-loving cricket, *Myrmecophila*. All species, except the *Stenopelmatus*, were more numerous in the disturbed area, probably because of the loosening of the rocks and the large fissures in the earth, providing places to hide during the day. One species of *Ceuthophilus* was found in only two areas of the entire test site—at the tunnel at Tippipah Spring and in Area 12A. The latter collections were made from the fissures which this species, primarily a cave-dweller, had likely invaded.

A great deal of time was spent during the month of August collecting in these and associated areas. During September, October, and November the studies were visited less frequently.

In addition to the can collecting, the sweeping of vegetation, and the collecting of the strong fliers with aerial nets, many hours were spent in overturning loosened rocks in the disturbed study as well as undisturbed rocks in both studies. Many fossorial Orthoptera were obtained in this manner.

Because of the difficulty of access and the distances involved, no night collecting was done in these studies.

Table 6 summarizes the results of collecting in the pinyon-juniper area of studies 12A and 12E.

Cane Springs. Immediately to the west of Frenchman Playa, but separated from it by a series of hills and ridges was one of the best habitats for Orthoptera at the test site. Cane Springs was situated on a north slope with drainage from the higher slopes to Frenchman Playa below. The water originated from a man-made tunnel and was empounded in a small reservoir. Natural vegetation of cat-tails, *Typha domingensis*, filled much of the reservoir, while dock, *Rumex crispus*, and water-parsnip, *Berula erecta*, were in the depressions. Nearby was an association of grass, *Elymus cinereus*, large shrubs, *Atriplex canescens*, and in the small valley below a good growth of salt grass, *Distichlis stricta*. The small reservoir, itself, was open at one end, but normally contained variable growths of algae and aquatic angiosperms. Several species of smaller plants, including grasses, grew around the more open ends.

The study, known as CM, or Cane Springs proper, was collected extensively and regularly.

Table 7 summarizes the results of collecting in the Cane Springs area. This table, however, does not include study CBA.

Transecting the upper edge of the Cane Springs area was study CBA, a line consisting of a series of sixteen can traps in a mixed vegetation association. The transect crossed most shrubs found on the bajadas of the Nevada Test Site and continued up the steep, sparsely vegetated slope to a low ridge.

The can traps on this line transect were open continuously from March 21, 1961, to March 24, 1962. They were checked three times per week, and each of the different plants along the transect was checked thoroughly for Orthoptera. Because of the ideal situation of this transect, this study was checked most thoroughly for any possible relationships between Orthoptera and the host plant.

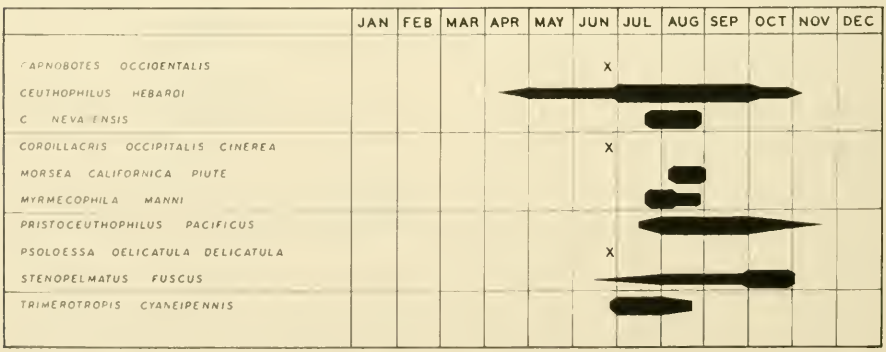


Table 6. Seasonal distribution of the Orthoptera characteristic of the Pinyon-Juniper habitat (Studies 12A, 12E).

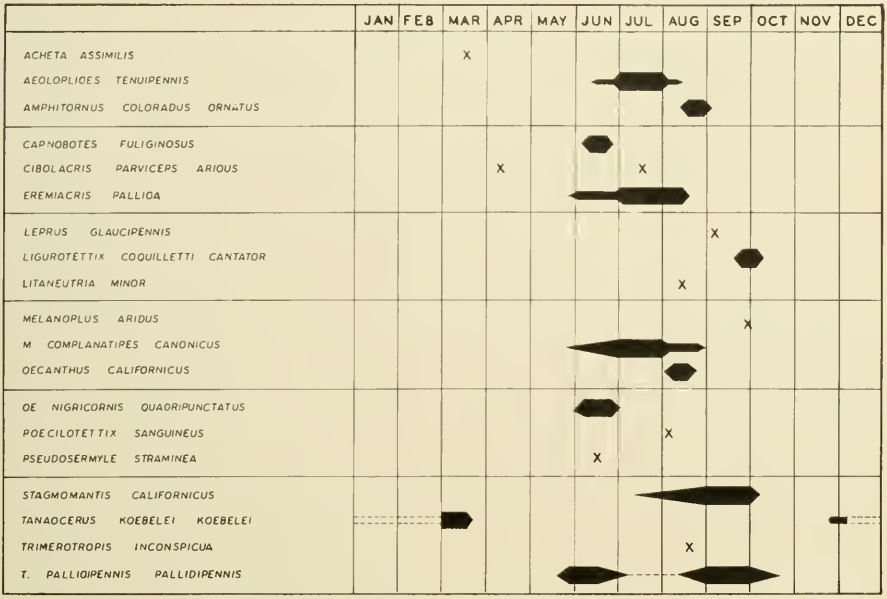


Table 7. Seasonal distribution of the Orthoptera characteristic of Cane Springs (Study CM).

No night collecting was possible in the Cane Springs area because it was restricted to daytime access.

Jackass Approach Area. (West of Mercury and southwest of Cane Springs) The quadrate study established as JA, in a mixed vegetation situation, was located along a rolling slope leading to Jackass Flats. The area was considerably more rocky than previously defined studies (except CBA at Cane Springs) and consisted of vegetation including *Lycium andersonii*, *Dalea polyadenia*, *Grayia spinosa*, and some *Larrea divaricata* and *Franseria dumosa*.

Can traps in this quadrate were open continuously from March 21, 1961, to March 24, 1962, and for three-day periods in the first and third weeks of each month from April 3 to May 18, 1962.

The most numerous species of Orthoptera in the area were *Ligurotettix coquilletti*, *Trimerotropis inconspicua*, and *T. pallidipennis*. At least 45 species of Orthoptera were collected in these studies of mixed vegetation, and no tabular summary is made.

Mercury Area. The Mercury campsite, as such, has been listed as study MD. Few records of Orthoptera are recorded for this area, which is not conducive to day-time collecting because of the lack of vegetation due to the presence of extensive asphalt or gravel surfaces. Because of the numerous lights, however, it was checked often at night for Orthoptera attracted to lights.

Miscellaneous Collecting Areas

In addition to the above regularly visited and collected areas, the following areas and studies were infrequently collected, or can traps were established for shorter periods of time.

Area 3. (Yucca Flat, immediately north of Yucca Playa) While several transects were being used for the purpose of collecting mammals by field biologists, the author visited a number of the studies for the express purpose of collecting Orthoptera. Studies 3CG and 3CH were associated with very light soil, and the whitish *Trimerotropis albescens* was well represented in the areas. Some night collecting was done in Area 3.

Area 12. Study 12D, known also as Whiterock Spring, consisted of a small intermittent stream-bed associated with white rock ledges from which originated a small amount of water. The area appeared to be a typical habitat of the pygmy locust, *Paratettix*, but none was collected. The vegetation was a mixed type including

some *Atriplex canescens*. The soil types were an extreme contrast: from the very dark reddish-brown soils of the surrounding areas to the white ledges and the white gravels of the stream bed.

Study 12CF was established in the approach to Kowich Valley at the junction of that road and the Rainier Mesa road. Concerted collecting was done on several occasions, resulting in the capture of *Trimerotropis fontana* and several other species. The area was one of sagebrush and bunch grass.

Sand Dunes-Target Rock Areas. These sand dunes on the test site are stationary type dunes in a very restricted area approaching south Rainier Mesa. The area was visited as frequently as possible during August through November. No early season collecting was done there, although it may have resulted in some species peculiar to that environment. The study known as ECA was originally a transect through the dunes. Bitterbrush, *Purshia glandulosa*, is primarily associated with the dunes themselves. Also in the area is *Juniperus osteosperma*, a tree cholla, *Opuntia* sp., *Atriplex canescens*, *Eriogonum fasciculatum*, and along the flats many species of small plants.

Five can traps were established in this study and maintained from August 16 to September 23, 1961. They were placed to take advantage of the best possible movement of fossorial Orthoptera.

The dunes were of very light-colored sand, and the light-colored *Trimerotropus albescens* was abundant. Also collected in this area were *Mestobregma impexum* (the only collection for the test site), *Melanoplus complanatipes* (found in direct opposition to the habitat of very heavy vegetation of Cane Springs), and *Morsea californica* (associated with *Purshia*).

Study ECB, originally a line transect, was also known as the Target Rock area. It consisted of the same type of white sand as at the sand dunes and was located in a long narrow valley approach to the south end of Rainier Mesa. It was covered by a rather dense growth of sagebrush, *Artemisia tridentata*, and *Atriplex canescens* on the shoulders of the graded road. Some junipers were in the area, especially along the marginal hills. The area was not extensively collected, but some time was spent on several occasions in overturning rocks in an attempt to capture any secretive orthopterans that might not otherwise be captured. No can traps were established in this area.

Tippipah Spring-Midvalley Areas. These areas, situated at higher elevations, were collected extensively on the few occasions they were visited. Due to the inaccessible nature of the areas, however, they were only visited several times during the course of the study.

A quadrate was established in Midvalley, study TA, following the patterns already outlined, but the can traps were closed except for a few days during each month. On several occasions while they were open, however, extensive collecting was done both with sweeping and aerial nets, and resulted in the discovery of an apparent isolated community of *Dracotettix plutonius* associated with *Artemisia tridentata*, which is dominant in the valley. The results of collecting are summarized in Table 5 with *Coleogyne*, as the sagebrush here is considered a subclimax to *Coleogyne*.

Study TCB, originally set up as a transect through the bottom of one of the small drainage canyons from the higher elevations to Yucca Flat, was another of the inaccessible areas visited only a few times. The vegetation in the bottom of the small rock-covered canyon was predominently *Purshia glandulosa*, with some *Atriplex canescens*, *Eriogonum fasciculatum*, and *Quercus gambelli*. The orthopteran *Morsea californica* was common on *Purshia* and *Leprus glaucipennis* was found along the steeper slopes. A new subspecies of *Insara elegans* was also collected on *Purshia*.

Study TE, known as Tippipah Spring, consisted of a man-made tunnel dug in the hillside. A perennial water supply was found in the protected confines of the tunnel, making it cool and humid. Several species of birds, rabbits, and one snake were found in the tunnel. This was the type locality of a new species of *Ceuthophilus*. The only other place this species was found, as discussed previously, was on Rainier Mesa associated with the cracks and fissures of the disturbed area. No other orthopteran was found in the tunnel proper, but some aeridids were found in the immediate vicinity. The vegetation was primarily sagebrush.

Numerous other studies were established at the test site as quadrates or transects. A considerable amount of collecting was done between the major established studies. Can traps were open in many areas for ten-day periods during late 1961 and early 1962. These were visited in the course of the study by the author or by field personnel associated with the ecology projects, but are not outlined here because of the limited collecting reported. Further comments on these areas will be made with the report of the individual species.

ENVIRONMENTAL RELATIONSHIPS OF THE ORTHOPTERA

The environmental factors which determine the distribution of the Orthoptera are not clearly understood, particularly as they pertain to a restricted area such as the Nevada Test Site. This is complicated by the fact that the Orthoptera as a group are not restricted to a particular plant. Isely (1937) based his studies in Texas on the correlation of the Acrididae and the distribution of soil types. Cantrall (1943), on the other hand, found that in Michigan it was easier to correlate the distribution of the Orthoptera with vegetation. At the Nevada Test Site some of the species can be correlated with vegetation, which is necessarily determined by soil types and other physiographic features. Because of the severe environment it is more meaningful to correlate the distribution of the Orthoptera, for the most part, with the vegetation.

Tables 1 through 7 have been prepared to show the seasonal relationships of the various species of Orthoptera in the major plant habitats. The earliest and latest observed records for each species are shown. The broadest part of the line in each case represents the maximum abundance. It is of the same width for all species, regardless of their comparative abundance to other species. It is assumed that each species is as abundant during any season as the conditions of its environment will permit, and the broadest part of each line therefore represents the maximum seasonal abundance and is equal to 100 per cent of the possible population density under the existing conditions.

The immediate environment of the fossorial Orthoptera is incident to that of the major plant community. The presence of any species is necessarily dependent upon such conditions as subterranean runways and nests of rodents, fissures and caves, rocks, and ground debris, or, in the case of the symbiotic *Myrmecophila*, the presence of an ant colony. These Orthoptera, nevertheless, are included with the major plant communities if they were collected in that particular plant habitat.

Where there is insufficient evidence to correlate the relative distribution or abundance of a species, each record for that species is plotted as "x" on the table.

A complete summary of the species of Orthoptera collected at the test site is given in Table 8.

CLASSIFICATION OF THE ORTHOPTERA

The classification of the Orthoptera has shown an evolution that parallels other insect groups. Interpretation of morphological characteristics by different individuals has resulted, in the past, in an emphasis of different entities above the rank of genus, for which there is no established priority. Many students in the Orthoptera have elevated lesser groupings to the rank of order, thus creating two or more orders out of what should actually be one diversified order. Numerous recent studies on detailed internal morphology, particularly the phallic complex of the male, the spermatheca and accessory organs of the female, as well as a re-evaluation of the external morphological characteristics has resulted in a more complex system of classification that actually simplifies an understanding to the Orthoptera. Some of the problems that have existed with reference to the relationships of certain groups are cleared up. As these studies continue this classification will undoubtedly change, as it has in the past.

It is exceedingly difficult to present a clear analysis of any major group in a limited area. Certainly a complete revision of a group is needed to point out special relationships. This present study, however, is not an attempt at revision of any group. From an evaluation of data derived from similar studies others can more properly bring about the major revisions. As an aid to such a study, this thesis will have been worthwhile.

The classification as used herein is modified from Rehn and Grant (1961) to include those insects definitely found or likely to be found at the Nevada Test Site.

Order Orthoptera

Suborder Caelifera
- Superfamily Acridoidea
  - Family Tetrigidae[1]
  - Family Eumastacidae
  - Family Tanaoceridae
  - Family Acrididae

[1]Families included only as hypothetical owing to the lack of extensive environmental areas at the Nevada Test Site in which members of the family would be found.

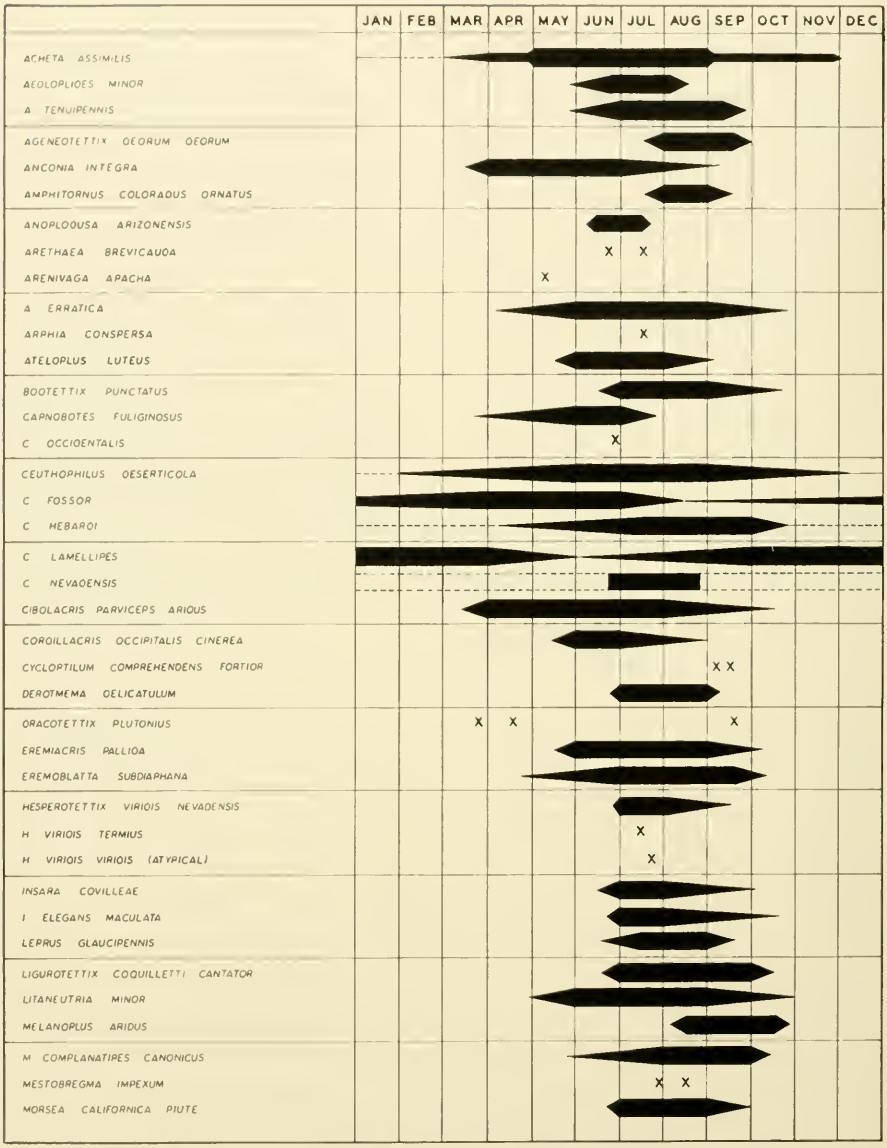


Table 8. Seasonal distribution of the Orthoptera.

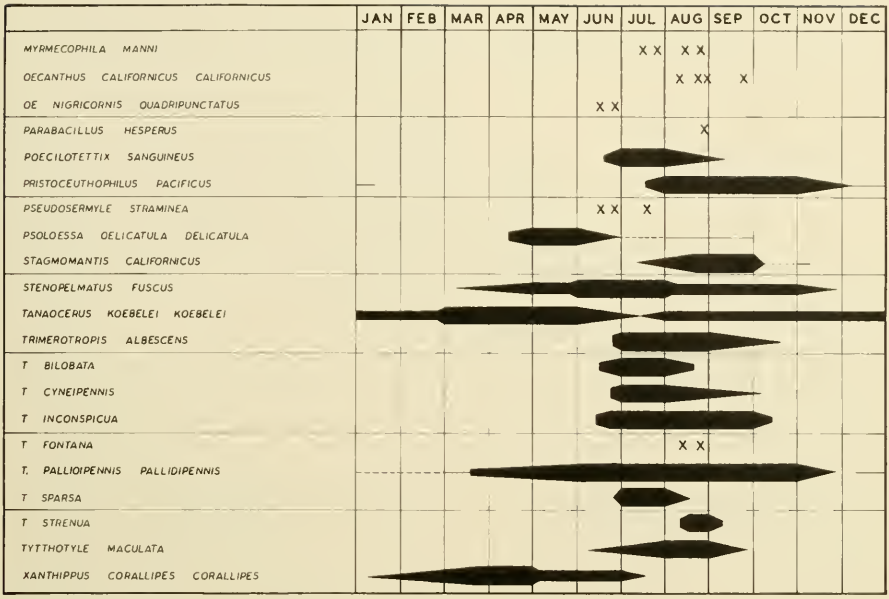


Table 8. Continued.

Superfamily Tridactyloidea
Family Tridactylidae[1]

Suborder Ensifera
Superfamily Tettigonioidea
Family Tettigoniidae
Family Gryllacrididae
Family Gryllidae

Suborder Phasmatoptera
Superfamily Phasmatoidea
Family Phasmatidae

Suborder Dictyoptera
Superfamily Mantodea
Family Manteidae
Superfamily Blattodea
Family Polyphagidae[2]

External Anatomy

(Plate 1; Figures 1-6)

The body of the Orthoptera is divided into three general regions, head, thorax, and abdomen, each of which bears certain essential parts and appendages used in classification. (See Albrecht, 1953, for detailed anatomy.)

The head is typically of an oval shape, except in certain groups in which it is variously produced. The anterior portion is called the frons, immediately below which and connected to it is the somewhat moveable segment, the clypeus. Along the frons and between the antennae is the frontal costa, variously modified according to the species and in some groups an important structure in the classification of that group. The upper surface of the head between the large compound eyes and in front of them is the vertex. This may be either horizontal or sloping forward in front of the eyes. The margins of the vertex are often well raised and sharp, and sometimes fairly broad; in the latter case they often bear regular depresions, called the foveolae of the vertex, which structures are important in taxonomy. That portion of the dorsal surface of the head immediately in front of the interocular space is the fastigium. The part of the head behind the compound eyes is the occiput. The lateral sides of the head, immediately below the occiput, and separated from the frons by a definite groove, the subocular suture, are the genae. Three simple eyes, or ocelli (occasion-

[2]No consideration is given to those roaches which may be established in the buildings, such as *Blattella germanica, Blatta orientalis, Periplaneta americana* and others, which under normal circumstances would not become a part of the natural fauna of the area.

ally only two are present in the Orthoptera, and they are rarely not evident or absent), are typically located, one at the middle of the frontal costa, a little below the base of the antennae, and two paired lateral ocelli close to the upper front margins of the compound eyes.

The appendages of the head are the antennae and the mouthparts. The antennae are multiarticulate. In some groups they are much longer than the body and consist of a very large number of small segments; in other groups a determinate number of segments, generally a relatively small number (not more than 28) of fairly large segments, the length of which seldom exceeds that of the entire body. The shape of the antennae is usually filiform and equally broad throughout, but in some species they are variously modified, ensiform or clavate. The mouth is mandibulate. The mandibles are usually of a grinding type. In addition to the pair of mandibles, a pair of maxillae with five-jointed palpi, a labium with three-jointed palpi, and a labrum, which structure is continuous with the clypeus, but distinct from it by definite sutures, are present.

The thorax consists of three segments, the prothorax, mesothorax, and metathorax, each of which bears a pair of legs. The prothorax is moveable to a degree, frequently developed into a dorsal structure which covers most or all of the mesonotum and sometimes the metanotum, and in one family even most or all of the abdomen. The shape and details of the pronotum are of great importance in the systematics of the Orthoptera, especially its raised ridges or carinae and transverse furrows. The mesothorax and metathorax are usually not freely moveable. The lower surface of the prothorax, or the prosternum, between the bases of the front legs, is more deeply sunk than that of the mesosternum and metasternum. In some groups of acridids this prosternum is provided with a raised tubercle or spine of different shapes. It is used as a criterion for separating subfamilies and for classification of some species within that subfamily. Its presence, however, is not restricted to one subfamily.

The two posterior segments of the thorax, the mesothorax and the metathorax, bear, in addition to the ventral or latero-ventral legs, the dorsal tegmina and wings, except in the apterous forms. In some species opposite sexes are alate and apterous, the female usually being the apterous sex. The true, or hind wings, attached to the metanotum, are sometimes very greatly reduced. The front wings, or tegmina, are fixed to the mesonotum. They are relatively coriaceous (hard or leathery), not folding and scarcely or not at all transparent. In the resting position they repose and are usually overlapping and closed over the dorsum of the abdomen and the more delicate hind wings, thus protecting them. The hind wings are usually more membranous, transparent (sometimes brightly colored), and furnished with radiating or divergent veins. When not in use they are folded like a fan under the tegmina. The hind wings are the active appendages where flight is possible, the tegmina being used more for balance. On the wings and on the tegmina is a complicated system of longitudinal and transverse veins, a study of which venation is often important in the classification of a species.

The limbs of the Orthoptera are simple in structure, or variously modified, and consist of coxa, trochanter, femur, tibia, and tarsus. The coxa is often provided with spines or projections meaningful to taxonomy. The tibia, and frequently the femur, is armed with spines (spurs, calcars, tubercles, spinules, etc.) on the sides and at the apex. The tarsus is one- to five-jointed, terminating in two claws, between which, in some groups, is an arolium. The proximal or first joint may also bear a plantula. The front limbs are ambulatorial, or occasionally enlarged, pincer-like and developed for grasping prey. The middle limbs are always ambulatorial, and the hind limbs are adapted for running, jumping, or walking.

The abdomen consists of several segments, connected by feebly sclerotized elastic membranes. Each segment is divided into upper and lower halves, called tergites and sternites, respectively. At the lower margin of each tergite a small opening, the spiracle, is visible, while the first tergite bears a large structure, the tympanal organ. This organ, if present, is located on the protibia of the Tettigoniidae and Gryllidae. The number of visible segments is different in the two sexes, while, even in the same sex, their arrangement is different on the dorsal and ventral side.

In the male there are eleven tergites, the 9th and 10th being partly or wholly fused. The 11th tergite is represented by the epiproct. Laterally to the epiproct, and arising independently from the membranous areas behind the posterior margin of the 10th tergite, are the cerci, developed as a single unit or multiariculate, and often important in taxonomy.

On the ventral surface nine sternites are visible, the 1st being fused with the metasternum, but still distinguished from it. The distal part of the 9th sternite forms the subgenital plate, an inflated structure in the male under which the

Plate I. Morphology of *Trimerotropis pallidipennis pallidipennis*. Fig. 1, female, lateral view; Fig. 2, female, head, facial view; Fig. 3, female, head and pronotum, dorsal view; Fig. 4. female, tegmen and wing; Fig. 5, female, apex of abdomen, lateral view; Fig. 6, male, apex of abdomen, lateral view.

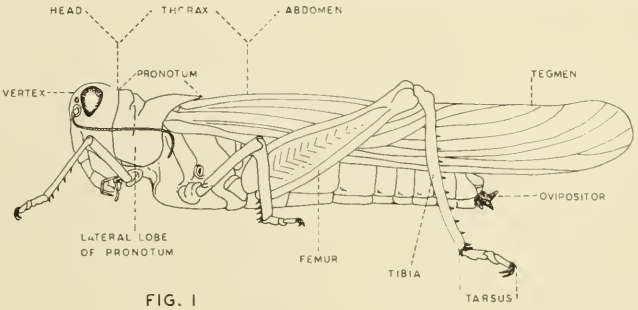


FIG. 1

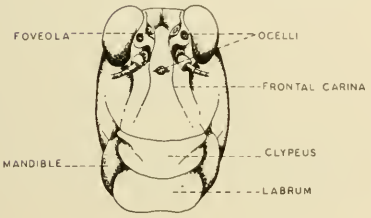


FIG. 2

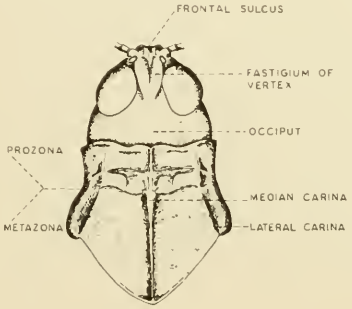


FIG. 3

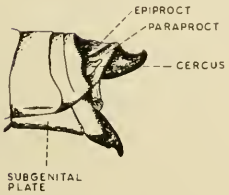
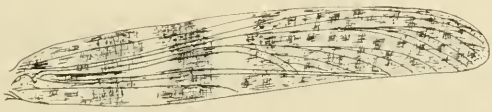
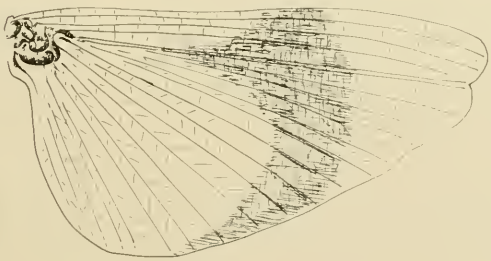


FIG. 5





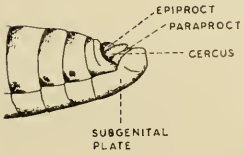


FIG. 6

FIG. 4

copulatory organs are concealed. The copulatory organs of the male are usually symmetrical, very rarely asymmetrical. The 10th sternite of the male is not visible externally in the adult and the 11th sternite consists of the latero-ventral plates or paraprocts associated with the epiproct, represented by the 11th tergite. The abdomen of the male thus terminates in a more or less conical, or obtuse, genital plate.

The sexes of the Orthoptera are easily distinguished. In the female there are also eleven dorsal tergites, the 11th segment forming the epiproct, as in the male. On the ventral surface, however, there are only eight sternites, the 8th being usually considerably longer than the others and called the subgenital plate. The 9th and 10th sternites are not visible externally and the 11th forms the paraprocts as in the male. The tip of the female abdomen is formed by the two pairs of valves of the ovipositor which resemble strong chitinous hooks or appendages. The shape of the ovipositer varies in different species in accordance with the conditions under which the eggs are laid, since its function is to prepare the hole in which the eggs are deposited. In the species that insert their eggs into the ground, the valves of the ovipositor are shaped like strong hooks, while in those species that lay their eggs in the stems of plants, the valves are built on the principle of a saw. Thus, different modifications of the ovipositors exist in the different groups. The genital structures of both sexes are important criteria to the classification of the Orthoptera.

NOTES ON DEVELOPMENT

The first nymphal instars are recognizable as Orthoptera and differ from the parents in size, in the total lack of wings, and external genitalia, and in the proportionately large head. Their metamorphosis is gradual (paurometabolous of some authors), the growth to adults being accomplished by a series of stages or instars, during which they feed ravenously. These stages are separated by periodic molts (ecdyses) of the chitinous exoskeleton. After ecdysis the insect increases rapidly in size before the body wall becomes rigid.

The wings, if present in the adult, appear in the third instar as slight backward outgrowths of the second and third thoracic nota. These wing pads increase in size with each subsequent ecdysis. They may extend over several segments of the abdomen in the last immature instar. The instar of the nymph can generally be determined by the comparative size of the wing pads.

The external genitalia are present in the ultimate or penultimate nymphal instar. After the series of usually five ecdyses the insect attains the adult form and does not again shed its exoskeleton.

ANNOTATED LIST OF THE ORTHOPTERA AT THE NEVADA TEST SITE

USE OF THE KEYS

Keys based on only the more salient characters are imperfect instruments. They are only partially descriptive, and are for convenience only, as they are intended as a short-cut in identification. In cases involving any doubt of identification, comparisons should be made with accurately determined specimens. In some instances a full description of the species in question may be checked. In the matter of descriptions the worker may run into difficulty. Early entomologists published descriptions to species that are completely inadequate, if not entirely useless. These descriptions perhaps identified the species known at the time of publication, but the constant addition of new species to the literature has limited the use of the original description to present-day useage. It may, therefore, be necessary to check a complete description given by a recent author. Descriptions used in this paper are, for the most part, incomplete and may be quite useless in some cases of mistaken identity or establishment of new records.

No taxonomic work is so complete as to be absolute. The keys presented here are confined to the species definitely known from the Nevada Test Site and some definitely known from surrounding areas. Others may eventually be found within the confines of the test site, necessitating a revision of the keys.

Most of the structures made use of in the keys are discussed in "External Anatomy" and are further identified by separate figures. These and additional structures, about which there may be some uncertainty, are illustrated in other drawings inserted near the keys as characters for easy reference.

Key to the Suborders of the Orthoptera

(Modified from Rehn and Grant, 1961. Any reference to groups not found in the present study area has been omitted.)

1. Caudal limbs saltatorial in type, the femur greatly enlarged (Fig. 1); pronotum generally developed as a large saddle-shaped structure covering most of thorax laterally and dorsally (Fig. 2); evident auditory organs generally present on proximal abdominal segment or on cephalic tibia; tarsi always less than five-jointed 2

   Caudal limbs ambulatorial or cursorial in type; pronotum compressed, flattened above and below or not markedly different from mesonotum and metanotum, never as in alternative; evident auditory organs not present; tarsi five-jointed 3

2. Antennae short, usually no longer than the head and pronotum combined (the chief exception being the family Tanaoceridae in which the antennae are slightly less than the total body length); antennal segments less than thirty in number, filiform or sometimes flattened; auditory apparatus, when evident, placed on each side of the proximal abdominal tergite (Fig. 3); female ovipositor composed of four short valves; caudal tarsi with three segments (Fig. 4) ..... Suborder Caelifera, page 22

   Antennae usually long, setaceous and with many minute segments, almost always exceeding the body in length; auditory apparatus present on cephalic tibiae (very rarely absent) (Fig. 5); female ovipositor usually long and and well developed, often spear-like or sword-shaped, rarely reduced in length, composed of four or six valves; caudal tarsi usually with four segments (Fig. 6) ..... Suborder Ensifera, page 81

3. Body very slender and elongate, of cylinderical, stick- or twig-like form; pronotum shorter than mesonotum or metanotum; tegmina and wings completely absent; cerci a single segment; no styles present on the subgenital plate of the male; ovipositor of female formed of six short valves, not surpassing the subgenital plate; limbs ambulatorial, long, similar in type; coxae never elongate, well separated .... Suborder Phasmatoptera, page 118

   Body ranging from slender and elongate (in Manteidae) to stocky and robust, somewhat flattened (in Polyphagidae); pronotum ovate or elongate, larger and more conspicuous

FIG. 1

FIG. 2

FIG. 3

FIG. 4

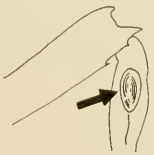


FIG. 5

FIG. 6

Figs. 1-6. 1, *Trimerotropis pallidipennis pallidipennis*, female, caudal appendage. 2, *T. p. pallidipennis*, female, pronotum, lateral view. 3, *T. p. pallidipennis*, female, proximal abdomen showing auditory apparatus, lateral view. 4. *T. p. pallidipennis*, female, caudal tarsus, lateral view. 5, *Capnobotes fuliginosus*, female, distal femur and proximal tibia, showing auditory apparatus, lateral view. 6, *C. fuliginosus*, female, caudal tarsus, lateral view.

than the mesonotum or metanotum; tegmina and wings generally present, but often reduced or absent; cerci multisegmented; styles present on the subgenital plate of adult male; ovipositor of female little developed; limbs all cursorial, or the cephalic pair strongly modified and developed as efficient raptorial organs, in the latter case with the coxae greatly lengthened, median and caudal coxae closely placed, often in contact ..... Suborder Dictyoptera, page 121

Suborder CAELIFERA

Key to the Superfamilies of the CAELIFERA

Antennae inserted mesad of the eyes (Fig. 7), and almost always with more than twelve segments; cephalic limbs of ambulatory type; cerci composed of a single segment; ovipositor of female formed by two pairs of opposed valves; caudal tarsi with three segments ..... Superfamily Acridoidea, page 22

Antennae inserted below the eyes (Fig. 8), and with from six to twelve segments; cephalic tibia of specialized type, adapted for fossorial habit (Fig. 9); cerci composed of one or two segments; ovipositor of female composed of four divergent valves; caudal tarsi with a single segment. Total length less than 10 mm. Superfamily Tridactyloidea, page 81

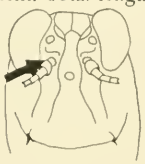


FIG. 7

FIG. 8

FIG. 9

Figs. 7-9. 7, *Trimerotropis pallidipennis pallidipennis*, female, head, facial view showing insertion of antennae. 8, *Tridactylus apicalis*, male, head, facial view showing insertion of antennae. 8, *T. apicalis*, male, head facial view, showing insertion of antennae. 9, *T. apicalis*, male, cephalic appendage.

Superfamily ACRIDOIDEA

The general form of these insects is largely of the so-called "grasshopper" type, although the body may be variously developed from extremely elongate to short and flattened. In size they range from the 8 mm. eumastacid male, the smallest species occurring at the Nevada Test Site, to the 50 mm. body, 100 mm. wing spread of the acridids. Some of the tropical acridids, not of this area, may achieve a wing-spread of over 200 mm.

Key to the Families of the ACRIDOIDEA

(Modified from Rehn and Grant, 1961)

1. Cephalic and median tarsi two-segmented (Fig. 10), caudal tarsi three-segmented, no arolium present between the tarsal claws; pronotum always extended caudad, covering all of mesonotum, metanotum, and generally, most or all of abdomen (Fig. 11); prosternum developed into a broad apron-like sternomentum which encircles a portion of the mouth parts; frontal costa ventrad of median ocellus always a single carinate ridge ..... Family Tetrigidae, page 23

   All tarsi three-segmented, arolium present between tarsal claws (Fig. 12); pronotum rarely extended caudad sufficiently to cover the remainder of the thoracic nota and much of the abdomen; prosternum not developed into a definite sternomentum 2

2. Abdominal spiracles situated in the terga; proximal abdominal segment generally with evident lateral tympanic membrane ..... Family Acrididae, page 29

   Abdominal spiracles situated in the latero-dorsal membrane between the terga and sterna; proximal abdominal tergites without evident lateral tympanic membrane, wingless 3

3. Antennae short and stubby, shorter than the caudal femora in both sexes (Fig. 13); frontal costa bicarinate ventrad of the median ocellus (Fig. 14); no specialized stridulatory organ present on the sides of the abdomen in the male sex ..... Family Eumastacidae, page 24

Antennae very long in the male exceeding the body length, in the female at least equalling the caudal femoral length; frontal costa, especially in the male, unicarinate ventrad of the median ocellus (Fig. 15); specialized stridulatory organ present in the male sex laterad on the third abdominal tergite ..... Family Tanaoceridae, page 27

FIG. 10

FIG. 11

FIG. 12

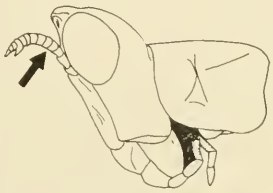


FIG. 13

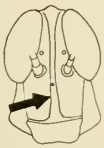


FIG. 14

FIG. 15

Figs. 10-15. 10, *Paratettix mexicanus*, female, distal tibia and tarsus of mesothoracic appendage, lateral view. 11, *P. mexicanus*, female, pronotum and tegmen, lateral view. 12, *Trimerotropis pallidipennis pallidipennis*, female, distal segment of caudal tarsus showing claws and arolium. 13, *Morsea californica piute*, female, head and pronotum, lateral view. 14, *M. c. piute*, female, head, facial view. 15, *Tanaocerus koebelei koebelei*, female, head, facial view.

Family Tetrigidae
Subfamily Tetriginae
(Figures 10, 11)

Members of this family are among the smallest of the Acridoidea and are commonly referred to as the pygmy or grouse locusts. They may be readily recognized by the prolonged pronotum, frequently with a very high median carina, which covers most or all of the abdomen, often including the terminal abdominal appendages. This specialization provides protection for the delicate wings and replaces the tegmina which have been reduced to small oval lobes or scales. The wings are usually present and well developed, the length varying with the length of the pronotum. Both long and short winged individuals, accordingly those with a long or short pronotum (macropronotal and brachypronotal of Rehn) are found in the same species.

The prosternum projects forward as a chin piece, the sternomentum, encircling the caudal section of the mouthparts. The arolium between the tarsal claws is absent, which may be correlated with the habit of resting on the ground instead of living on plants. The front and middle tarsi are two-segmented, the caudal tarsi three-segmented. The subgenital plate of the male is conical or triangular. The cerci are very small. The female may be recognized by the serrulate ovipositor with sharp diverging extremities.

The Tetrigidae are found in practically all habitable areas of the earth, even to relatively high elevations. They occupy a variety of terrestrial habitats, but are nearly always associated with damp situations or water and are generally common along streams and other bodies of water. They feed upon algae, lichens, mosses, sprouting seeds, sedges, and other tender plants and debris.

Their coloration is protective, resembling the soil background in pattern, and, although often varied, is never such as to make the insect conspicuous in its habitat. Individual and local variations are obvious and overlap geographically, adding to the complexity of the group.

Representatives of this family have not been actually collected from the Nevada Test Site, but the area is within the range of two species. These insects could survive only in the areas within the confines of the test site where there is a perennial water source, such as at Cane Springs or Whiterock, questionably on Rainier Mesa, and perhaps could become established around some of the water tanks in the areas. Numerous attempts were made to secure these insects in the possible habitats at the test site.

Paratettix mexicanus (Saussure) has a very wide distribution over much of the western United States, and is definitely known from Beatty and Ash Meadow in Nye County, and Las Vegas, Clark Co., Nevada (Rehn and Grant, 1957).

Paratettix aztecus (Saussure) has been collected in the Panamint Mountains and Panamint Valley, as well as other localities in Inyo Co., California (Rehn and Grant, 1957), and conceivably could be found in the confines of the test site.

The genus *Paratettix* can be recognized by the fastigium, which is hardly, if at all, produced cephalad of the eyes. As seen from the dorsum the fastigium is narrower than one of the eyes.

The two species which may be found in the area are distinct according to the condition of the median femora. In *mexicanus*, the median femora have two or three pronounced lobes on the ventro-external margin and are lobulate or undulate (or even simply carinate) on the dorsal margin. In *aztecus*, the ventro-external margin is at most undulate or loculate, never truly lobate. The preferred habitat of *mexicanus* is on or near mucky ground, in the vicinity of standing or running water, but it has been collected on bare sand in temporary dry creek beds. "In its desert environments, while the surroundings may otherwise be exceedingly dry and arid, it is met with only near water, if only a small seep or a tiny rill, or in a spot where limited ground moisture is present." (Rehn and Grant, 1961) On the other hand, *aztecus* "is more definitely saxicolous . . ., its general preference being for stony or gravelly situations near water. These may be the stony margins of rivers or streams, along rills on rock slopes, or about 'tinajas', or rock water pockets." (Rehn and Grant, 1961)

Family EUMASTACIDAE

Subfamily MORSEINAE

The name by which these insects are commonly known is eumastacids, although some entomologists have applied the name "monkey grasshoppers" because of the agility by which they move along the branches and twigs of brush and chaparral.

They are of relatively small size (the smallest acridoid insect collected at the Nevada Test Site was a male of this family measuring 8.2 mm. in total body length) and completely wingless. The family as now recognized is predominantly a tropical one, is well distributed throughout the southwestern United States, but infrequently encountered because of the natural habits of the insects.

The head of the eumastacids is remarkably enlarged, projecting dorsad beyond the cephalic margin of the pronotum. The 12- or 13-segmented antennae are shorter than the combined length of the head and pronotum. The male subgenital plate is simple, the proximal abdominal tergite without evident lateral tympanic membrane. Abdominal spiracles are situated in the latero-dorsal membrane. Females have one or more abdominal tergites preceding the epiproct with a marked medio-longitudinal fold or fissure. The mesosternum and metasternum are strongly united into a more obviously single structure than in the Acrididae. The caudal femora are without the dorso-proximal overhanging lobe found in most acridids. The caudal tibiae have two pair of distal spurs (calcaria) and a tarsal arolium is well developed.

Only one species has definitely been collected at the Nevada Test Site, but because of the range of distribution of other species approximating the test site boundaries, they, too, are included in the keys and are discussed.

Key to the Genera of the EUMASTACIDAE

(Modified from Rehn and Grant, 1961)

Antennae with thirteen segments, node on ventral surface of 10th segment (Fig. 16); male cerci subcompressed, falcate distad (Fig. 17); subgenital plate of male with a recurved, median dorso-proximal sclerotized linguiform process (Fig. 18). Form as a whole more slender; frontal costa narrower proportionately than in the same sex of the alternate category . . . . . *Morsea* Scudder

Antennae with twelve segments, node on ventral surface of 9th segment; male cerci tapering, not falcate; subgenital plate of male without a recurved median dorso-proximal sclerotized linguiform process. Form as a whole more robust; frontal costa broader proportionately than in the same sex of the alternate category . . . . . *Psychomastax* Rehn and Hebard

FIG. 16

FIG. 17

FIG. 18

Figs. 16-18. *Morsea californica piute*. 16, female, antenna, lateral view. 17, male, cercus, lateral view. 18, male, apex of abdomen, dorso-caudal view.

Genus *Morsea* Seudder

1898. *Morsea* Seudder, Psyche, VIII, p. 179.

Morsea californica piute Rehn and Grant

(Figures 13, 14, 16-18; Table 9; Map 1)

1958. *Morsea californica piute* Rehn and Grant, Trans. Amer. Entom. Soc., LXXXIV, pp. 239-250, figs. 18-22.

Distinctive Features. Form slender and elongate, the males especially with deep, narrow head and very large and prominent eyes. Antennae with thirteen segments, with a ventral spiniform tooth on the 10th. Pronotum long in relation to depth, about twice as long as deep in males; ventro-caudal angle of lateral lobes rounded, especially evident in females. Male cerci falcate, the subgenital plate with a median, dorsal, anteriorly projecting linguiform process. Caudal femora with medio-dorsal and dorso-lateral minute, spiniform processes; genicular lobes similarly armed. Tarsal claws asymmetrical.

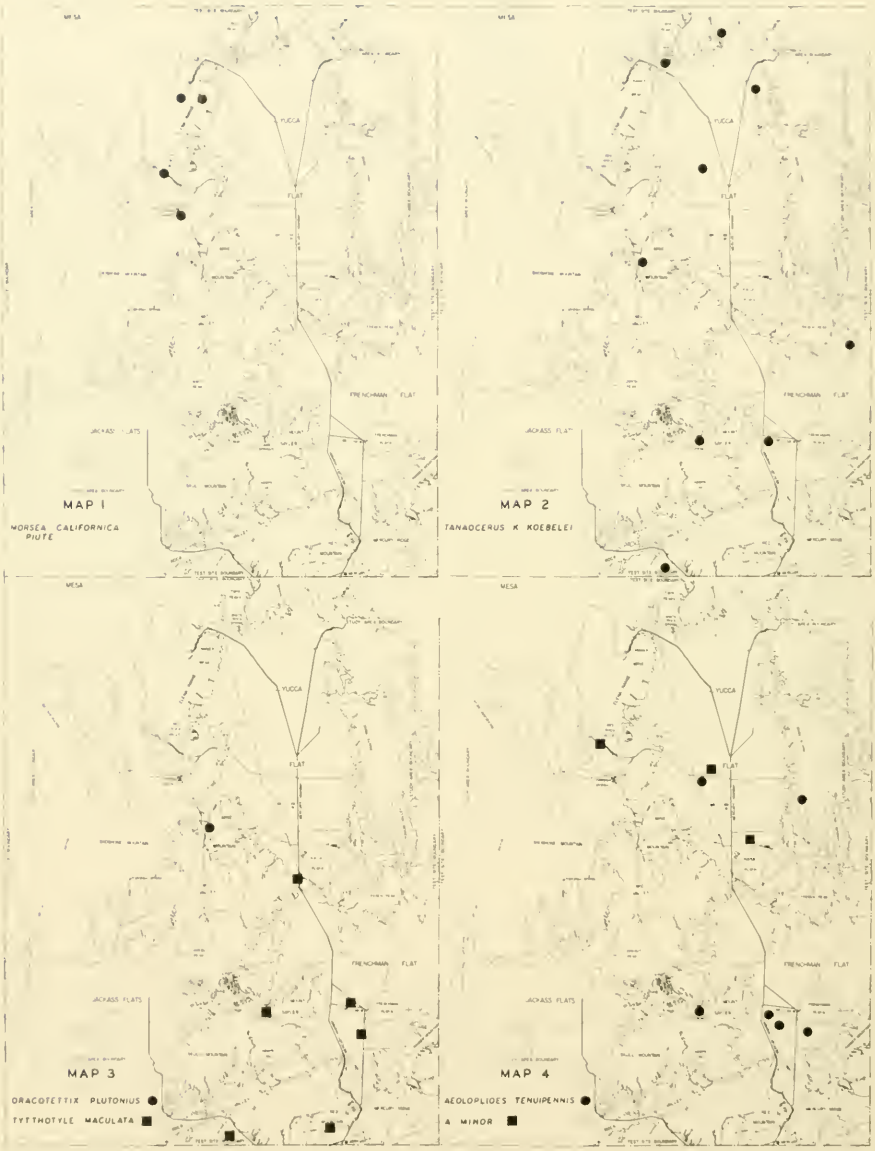
Size Variation. The series from the Nevada Test Site represents nymphs from 2.9 mm. long to adults. Size variation of adults selected at random are given in Table 9.

As discussed previously, the total length of the insect is probably the least accurate measurement because of the abnormal stretching of the abdomen of the female and the abnormal curvature of the abdomen of the male. The above measurements of total body length of females are considerably larger than previously published measurements. There is a possibility, of course, that the Nevada Test Site specimens represent atypical forms, intermediate between *M. californica piute* and *M. californica californica*, a more western form which averages larger. The proper placement cannot be made without comparison to typical specimens of that subspecies.

Coloration. This subspecies as represented by the series from the test site is more variable in color phases than in morphological characteristics. This same variation is noticeable in a series of specimens from Utah (3 miles southwest of Shivwits Indian Reservation on U.S. Highway 91, Washington Co., Utah, September 9, 1959, A. H. Barnum, on desert-almond, *Prunus fasciculata*, and cliff-rose, *Cowania mexicana*, and from Nevada (Lee Canyon, Clark Co., Nevada, August 13, 1961, A. H. Barnum, from bitterbrush, *Purshia glandulosa*. In coloration the nymphs are light brown or tan, occasionally gray-brown, rarely dark; the adult coloration is brownish-black, with an occasional gray-brown or tan individual. No correlation could be made with reference to habitat, sex, or color phase, as individuals collected even from the same shrub, or from the same group of shrubs in one area

Table 9. Size variation of *Morsea californica piute*.

	Length Body	Length Antenna	Length Pronotum	Length Cephalic Femur	Length Median Femur	Length Caudal Femur
♂, TCB, July 16, 1961	8.2		1.4			7.0
♂, 12A, Aug. 21, 1961	8.9	1.5	1.4	2.0	1.9	6.2
♂, ECA, Aug. 12, 1961	9.0	1.4	1.5	2.1	2.0	6.8
♂, TCB, July 16, 1961	9.6	1.6	1.5			7.3
♂, Measurements of Rehn and Grant (1961)	8.3-10.5	1.7-2.3	1.4-1.7	1.8-2.5	1.8-2.3	6.4-8.5
♀, TCB, July 16, 1961	14.9	1.4	1.7			
♀, 12E, Aug. 24, 1961	15.3	1.2	1.9	2.2	2.1	8.0
♀, ECA, Aug. 12, 1961	15.8	1.4	1.8	2.1	1.9	8.3
♀, ECA, Sep. 30, 1961	16.4	1.6	1.8	2.2	2.2	8.0
♀, 12A, Aug. 21, 1961	17.2	1.5	1.9	2.3	2.3	8.8
♀, Measurements of Rehn and Grant (1961)	10.0-12.1	1.9-2.8	1.5-1.8	2.2-2.8	2.0-2.6	7.3-9.3


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 1
NORSEA CALIFORNICA
PIUTE
MAP 2
TANAOCERUS K KOEBELEI
MAP 3
ORACOTETTIX PLUTONIUS
TYTTHOTYLE MACULATA
MAP 4
AEOLOPLIDES TENUIPENNIS
A MINOR

exhibited degrees of variation. The majority of specimens have the caudal margins of the lateral lobes of the pronotum contrastingly light colored. This light coloration extends (especially in males) along the entire ventral border of the lateral lobes. The males usually have darker postocular bars, this condition obviously somewhat reduced in darker phases.

Distribution. In their recent revision of the genus, Rehn and Grant listed the range of this subspecies as extensive in the Great Basin. It extends from California, in the Mono Lake region to Beaver County, Utah, and from northwestern Arizona to White Pine County, Nevada. It intergrades with the other four subspecies in the peripheral margins of its distribution.

Habitats. The preferred host plant of this insect is bitter-brush (*Purshia glandulosa*), and the insect was captured wherever this shrub was present on the Nevada Test Site. It was also collected from *Artemisia tridentata* in one area where *Purshia* was absent from that immediate area.

The insect is very difficult to capture because of its concealment on the shrubs. Its coloration and markings blend in well with the leaflets of the shrubs and with the small twigs upon which it rests. The insect can very rarely be seen by direct observation, but is best collected by beating the shrubs with nets. Characteristically it perches with its caudal legs relaxed in a lateral position, thus more resembling the tridentate appearance of the bitterbrush leaves.

Seasonal Occurrence. The collection of *Morsea* from the test site was sporadic because of the inaccessibility of the areas where it is found. The earliest collection of nymphs was June 22 and adults appeared as early as July 13. The last recorded appearance is September 30. It almost assuredly occurs in adult form into October and possibly November. Its greatest abundance is during the month of August.

Localities Represented. Specimens examined (nymphs and adults): 65.

Study TCB, near Tippipah Springs, 37 specimens, from June 22 to July 16, on *Purshia glandulosa.*

Study ECA, on sand dunes, 25 specimens, from August 11 to September 30, on *Purshia glandulosa.*

Study 12A, Rainier Mesa (disturbed area), 2 specimens, August 21, on *Purshia glandulosa.*

Study 12E, Rainier Mesa (undisturbed area), 1 specimen, August 24, on *Artemisia tridentata.*

Genus *Psychomastax* Rehn and Hebard

1918. *Psychomastax* Rehn and Hebard, Trans. Amer. Entom. Soc., XLIV, pp. 225, 242.

Specimens belonging to this genus have not been collected at the Nevada Test Site, but the genus is restricted in its distribution to southwestern Nevada and southern California, and may eventually be found on the test site.

This genus is more robust but less attenuate in form than *Morsea*, but it resembles that genus in that they are both apterous. The head is not as deep in relation to its breadth. The antennae have twelve segments with the ventral spiniform tooth present on the 9th segment. The pronotum is deeper in relation to its length, the ventrocaudal angle of the lateral lobes is angulate rather than rounded. Male cerci are styliform, flattened on the mesal surface; the male subgenital plate without a dorsal linguiform process. The caudal femora have their apices (including the genicular lobes) armed as in *Morsea*, but the tarsal claws are more symmetrical.

Three species and subspecies have been collected in the vicinity of the Nevada Test Site. *Psychomastax psylla inyo* Rehn and Grant has been collected in Inyo County, California, at elevations of 9500 to over 10,700 feet (Rehn and Grant, 1959a), which elevation limits would probably be out of the range of any of the areas at the Nevada Test Site. *Psychomastax deserticola indigena* Rehn and Grant was described from one female collected on the "west base of Belted Peak, Nye Co., Nevada, elevation, 6700 feet".

The species most likely to be found on the Nevada Test Site is *Psychomastax robusta* Hebard, the type locality being Charleston Peak, Nevada. It has also been collected at Lee Canyon at 6,000 feet and in eastern California. It is apparently "restricted to the mountainous areas of southwestern Nevada and adjacent southeastern California" (Rehn and Grant, 1961). It may possibly be found on some of the higher mesas and mountains of the Nevada Test Site.

Family Tanaoceridae

Members of this family, which was recently removed from the Acrididae (Dirsh, 1955), appear very early and are seldom encountered by collectors. They are remarkably agile, especially the males.

They are of medium size, the male moderately elongate, the female relatively robust. They differ from the Acrididae by the frontal costa which consists of a single carina ventrad

of the median ocellus, suggestive of the Tetrigidae in that respect. The antennae are slightly longer than the body (males), or slightly shorter (females). Wings are completely absent. The stridulatory ridge is located on the side of the third abdominal segment and on the lower internal basal margin of the caudal femur. The caudal tibiae have the external apical spine present, as in the Romaleinae of the Acrididae. Because of the presence of this external apical spine the group was considered to belong to the Romaleinae. Recent research on the male and female internal genitalia, however, by many entomologists, has straightened out the complexity of many of these aberrant species. The subgenital plate of the male is composed of two or three sclerotic plates connected by a membrane.

According to Rehn and Grant (1961) "the tanaocerids are an endemic North American family restricted to southwestern United States and extreme northern Baja California, Mexico. The family is known from the states of Utah, Nevada, Arizona and California. It is found only in the Upper and Lower Sonoran Life Zones."

One representative of this family is known from the Nevada Test Site.

Genus *Tanaocerus* Bruner

1906. *Tanaocerus* Bruner, Biol. Centr.-Amer., Orth., II, p. 191.

Tanaocerus koebelei koebelei Bruner

(Figure 15; Table 10; Map 2)

1906. *Tanaocerus koebelei* Bruner, Biol. Centr.-Amer., Orth., II, p. 192.

Distinctive Features. Surface moderately rugose, pronotum with numerous short rugae and rounded tubercles.

Fastigium, in profile, sloping ventro-cephalad continuous with frontal costa which is arcuate in profile; lateral carinae continuous with those of frontal costa which are rather widely separated and only weakly sulcate between. Head, in frontal aspect, with moderately marked supplementary carinae. Median carina of pronotum moderately evident, entire, usually finely sulcate; cephalic margin subtruncate, caudal margins truncate or very lowly arcuate with shallow crenulations; lateral carinae absent; lateral lobes with caudal margin weakly sinuate. Medio-dorsal carina of abdomen tectate, finely, but evidently, sulcate in proximal segments; lateral carinae absent; males with stridulatory ridge on side of third abdominal tergite; epiproct apically acute, especially in females. Subgenital plate truncate in females.

Nymphs can be recognized by their long antennae. This is the only acridid found at the Nevada Test Site with extremely long antennae, the antennae of instars of all other species being very short. All instars are represented in the collection from the Nevada Test Site, the smallest, representing the first instar, being 4.6 mm in total body length and with antennae 3.5 mm long.

Morphological Variation. Considerable variation is noted in the degree of surface tuberculations among specimens. Some specimens are much more rugose than others.

Size Variation. The series from the Nevada Test Site represents nymphs from 4.6 mm long, as previously noted, to adults. Sizes of adults selected at random are given in Table 10.

Coloration. The series of specimens from the Nevada Test Site shows considerable variation in coloration, the base color being dark mottled with buff or grayish-white. A number of specimens are particularly maculate, the degree of maculation corresponding to the degree of rugae and tubercles. (This maculate tendency

Table 10. Size variation of *Tanaocerus koebelei koebelei*.

	Length Body	Length Pronotum	Length Caudal Femur	Breadth Caudal Femur
♂, 5A, March 11, 1961	8.9	1.6		
♂, 5A, March 11, 1961	8.0	1.7	7.7	1.7
♂, Measurements of Rehn and Grant (1961)	8.0-8.9	1.7-2.4	6.9-8.0	
♀, 5M, March 11, 1961	17.6	3.2	8.9	2.4
♀, 4M, March 13, 1961	15.6	3.2	9.5	2.3
♀, 5M, April 1, 1961	18.9	3.2	9.2	2.4
♀, TA, April 8, 1961	17.8	3.6	10.4	2.1
♀, Measurements of Rehn and Grant (1961)	19.1-23.1	3.3-4.2	8.8-11.4	

is also seen in a series in the author's collection from Washington County, Utah [in the vicinity of Terry's Ranch, Beaver Dam Wash, April 17, 1952, and April 2, 1960, all adult]. The environment is very similar to that at the Nevada Test Site.)

Distribution. The distribution of this form occurs "from extreme southwestern Utah, west to Nye County, Nevada, and Inyo County, California. From its northern limit, the subspecies is found southward in eastern Kern, western San Bernardino and eastern Los Angeles counties, California. It intergrades with *T. k. albatus* in southeastern Los Angeles County, southwestern San Bernardino County and northwestern Riverside County" (Rehn and Grant, 1961).

It has been collected, but not found common, throughout most of the range of the Nevada Test Site. It is probaby more common than is indicated by the records because of its early appearance and difficulty of collecting.

Habitats. According to observed records this species inhabits both the Upper and Lower Sonoran life zones over a broad range of desert environments. Nymphs are generally associated with vegetation and can best be collected by sweeping with nets. The adults apparently prefer the ground covered with small pebbles or coarse gravel, in which environment they are adequately concealed and seen only when disturbed. Characteristic areas are vegetated by *Yucca brevifolia* and early spring ephemerals.

Seasonal Occurrence. Adults have been collected from January 9 to May 1. One first instar was collected in July and immature specimens have been collected in all months to the middle of March. The series of nymphs shows a gradual increase in size. They overwinter and appear as adults when optimum conditions are reached throughout late winter and early spring.

Localities Represented. Specimens examined (nymphs and adults): 66.

Study TA, Midvalley, 26 specimens, from March 15 to August 18 (July and August specimens all nymphs), in an area of *Artemisia tridentata*. Very few specimens actually collected off vegetation.

Study 10D, 1 specimen, March 13, in *Coleogyme ramosissima* area.

Study 5A, 8 specimens, January 9 to August 31, in *Larrea divaricata* area.

Area 4, 4 specimens, March 13 and August 26, vegetation unidentified but probably in *Grayia-Lycium*.

Area 12, 1 specimen, March 16, vegetation unidentified.

Area 15, 1 specimen, November 28, vegetation unidentified.

Study JA, Jackass approach of mixed vegetation, 17 specimens, January 9 to April 8 (adults), and August 13 to December 28, also January, February and March (nymphs).

Study CM, Cane Springs, 7 specimens, February 26 to March 14 and (one nymph) November 27.

Study NCC, 1 nymph, November 7, vegetation unidentified.

Family Acrididae

This family comprises the exceedingly numerous and common "short-horned" grasshoppers (as distinct from the "long-horned" grasshoppers belonging to the superfamily Tettigonioidea). They are found throughout the entire year but are common and abundant from early spring to late autumn. The family includes all the economically important migratory locusts or grasshoppers, so well-known throughout recorded history. Over one thousand genera and well over ten thousand species of world-wide distribution are known in the family. All members of this family feed on plant material and often are important insect pests. Most of the damage is done by a small number of species, but many others may do some damage at times.

They are characterized by relatively short antennae, usually shorter than the body, filiform, ensiform, or clavate, with the segments distinct. There are three ocelli, two laterad and one mesad in the frontal costa. The frontal costa is well marked, never replaced ventrad of the median ocellus by a single carina as in the Tanaoceridae. The lateral temporal foveolae are usually present, frequently well marked and sharply outlined, varying in position, and important to the classification of the group. The eyes are lateral, usually relatively large.

The pronotum is proportionately large, variously produced and ornamented. The dorsal surface, or disk, usually has a distinct medio-longitudinal carina which may be elevated into an entire or interrupted crest. The lateral carinae defining the lateral margins of the disk may or may not be present. A single transverse sulcus is almost invariably present, this being the caudal sulcus; anterior sulci may also be indicated. That portion of the pronotum anterior to the principal sulcus is termed the prozona, that posterior is the metazona.

The tegmina are fully developed and usually narrowly elongate, occasionally brachypterous, or even apterous, sometimes present in the male and absent in the female. When present they are always at least as long as the wings, usually dull-colored and thickened or coriaceous. In numerous cases certain veins of the marginal or discoidal fields may be specialized for stridulating purposes. Hind wings are developed according to the tegmina, from fully developed to very abbreviate, or absent, but never exceeding the tegmina in length. In some cases the radiate veins of the wings are thickened and rod-like, and their surfaces are specialized, along with certain veins of the anterior field and the anal complex, for stridulating purposes. The membranous hind wings may be brightly colored and very attractive, especially noticeable in the species found in the southwestern deserts.

The auditory organs are with few exceptions (in some apterous species) on the side of the proximal tergite. The external genitalia of both sexes are basically as in the other families of the Acridoidea. The abdominal spiracles are placed ventrad in the sides of the dorsal sclerites, not in the membrane as in the Tetrigidae and Eumastacidae. The prosternum is with or without a median spine or tubercle. When present this is usually well marked, and its form varies in different groups.

Cephalic and median limbs are short, relatively slender, usually subequal in size and general form. The caudal femora are much larger, saltatorial. Stridulating organs are often located on the inner side of the caudal femora. All species in the family show the outer surface of the caudal femora with the same type of impressed striae. The caudal tibiae have their extensor margins armed with spaced spines for the greater part of their length, and two distal spurs (calcaria) are found on each side. The tarsi of all limbs are composed of three segments, the proximal one (the metatarsus) with three pads or pulvilli. The tarsal claws have a distinct pad or arolium between them.

In recent years application of the male and female genital structures, both external and internal, have been regularly applied to many orders of insects. These structures have been especially useful to show phylogeny both within a group and the relationships of different groups. The male organs of intromission have been especially useful in revisions of several acridoid genera, and overall studies of the epiphallus of the superfamily Acridoidea have been made to establish certain families and subfamilies.

The phallic structures for many species of Acrididae have been described by several authors, and the relationships of the subfamilies and families of the Acridoidea have been revealed. As a matter of fact, the present scheme of Orthoptera phylogeny is a result of these studies.

The Acrididae contains species which are highly variable. The large body size and environmental differences to which species are subjected are undoubtedly responsible for this variation for the most part. This is especially true of species from western North America which may be subjected to extremes of altitudes, temperatures and general habitat, and also for species throughout the western hemisphere.

Environmental conditions play an important part in variation of external morphological characters, but internal characters such as the phallus should be less variable, except as may be incidental to external changes. These highly variable characters can not often be relied upon as a basis for classification. Apparently the more bizarre a structure may be, such as a cristate median pronotal carina, the more variable it is. In a number of recent studies based on the internal genital structures of the male, on the other hand, it was found that the so-called phallic complex and especially the epiphallus of the male, and the shapes and relationships of the valves of the cingulum and the apical valves of the penis are not subject to variation to any great degree, and when it does occur it is found in a complex species group which occurs over an extended area.

There appears to be little variation in the genital structures of any species. Such variation may result from the different techniques of dissecting or treatment of the dissected structures. The degree of sclerotization of parts is obvious and especially apparent when teneral specimens are examined. The sclerotization of internal structures apparently proceeds more slowly than externally, and specimens which are apparently completely sclerotized externally show internal teneral conditions. The determination of whether or not a specimen is fully mature is problematical, but important, and can best be determined by the internal structures.

Anyone who is going into a serious study of the Acrididae would benefit by a detailed study of the internal genitalia, especially of the male. As previously stated, these structures are less variable than the external characters. Only the external characters are used as criteria in the following key, so it is limited in use to the immediate area.

Key to the Subfamilies of Acrididae

1. External distal spine of caudal tibia present, with the appearance of three apical external spurs[3] (Figs. 19 and 20); median carina of pronotum ranging from virtually obsolete to strongly elevated; wings reduced or fully developed in both sexes ..... Romaleinae, page 31

   External distal spine of caudal tibia absent (in species at the Nevada Test Site) 2

2. Prosternum armed with some type of process, usually a spiniform tubercle (Fig. 21); wings reduced, sometimes with marked sexual difference, or fully developed ..... Cyrtacanthacridinae, page 35

   Prosternum rarely armed with any type of process, generally relatively flat (if a flat transverse prosternal process is apparently present, then the species is elongate, the form being very slender and linear); wings generally well developed, rarely reduced, never apterous, often brightly colored; pronotum often with a marked well elevated median carina ..... Acridinae,[4] page 48

FIG. 19

FIG. 20

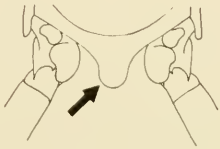


FIG. 21

Figs. 19-21. 19, *Tytthotyle maculata,* male, distal tibia and proximal tarsus of caudal appendage, lateral view. 20, *Dracotettix plutonius,* female, distal tibia and proximal tarsus of caudal appendage, lateral view. 21, *Melanoplus complanatipes canonicus,* female, prosternal spine, cephalic view.

Subfamily Romaleinae

The common name of "lubber grasshoppers" has been inappropriately applied to the members of this subfamily, inasmuch as many of them are winged (often with brightly colored hind wings) and very graceful in appearance, though large. Others, suggestive of the true "lubber" condition are completely wingless or have these organs greatly reduced. The family is principally tropical in distribution.

The subfamily exhibits a great diversity in external appearance, and the two species found at the Nevada Test Site show little external similarity. The internal genitalia must be studied to show this true relationship.

Key to the Genera of Romaleinae

(Modified from Rehn and Grant, 1959b)

Median carina of pronotum very high, lateral carinae well developed (Fig. 22); tegmina and wings shorter than the abdomen in both sexes; fastigium with a marked rostral development; pronotum with surface rugose, caudal margin of disk with distinct spaced nodules ..... *Dracotettix* Bruner

[3]The world-wide subfamily Cyrtacanthacridinae shows the general presence of the external distal spine of the caudal tibia. The spine is absent, however, in two genera, one of which is North American. The genus *Spaniacris* is apparently limited in distribution to extreme southern California in the Coachella and Imperial valleys. There is no obvious "third spine" in the genera presently under consideration, and this key character is reliable only for this immediate area.

[4]The subfamily Oedipodinae is now considered as a part of the Acridinae. The variability of intermediate forms with respect to such external characters as the median carina of the pronotum, the lateral profile of the face, the presence or absence of stridulatory mechanism on the caudal femora, the presence or absence of an intercalary vein of the tegmina, can not be relied upon for the separation of these groups. Recent studies on the internal genitalia lead to a synonymizing of this old subfamily Oedipodinae and an inclusion of these genera in the Acridinae. (See Rehn and Grant, 1960, for discussion of this problem.)

Median carina of pronotum obsolete to subobsolete; no lateral carinae present on disk (Fig. 23); fully winged in both sexes. Lastigium rather broadly rounding into the frontal costa; pronotum relatively smooth; the prozona of the disk rounded transversely.

Tytthotyle Scudder

FIG. 22

FIG. 23

Figs. 22-23. *Dracotettix plutonius*, female, head and pronotum, lateral view. 23, *Tytthotyle maculata*, female, head and pronotum, lateral view.

Genus *Dracotettix* Brunner

1889. *Dracotettix* Brunner, Proc. U.S. Nat. Mus., XII, p. 50, pl. 1, Fig. 1.

Dracotettix plutonius Brunner

(Figures 20, 22; Table II; Map 3)

1893. *Dracotettix plutonius* Brunner, North American Fauna, VII, p. 267.

Distinctive Features. There is no other species in the area with which this could be confused. The produced rostrum (best seen in lateral outline), the distinctive pronotal crest, the broad linguiform prosternal spine, and the abbreviated tegmina and wings will distinguish the species.

Size Variation. There is a remarkable sexual dimorphism in this species, the females being considerably larger. No comparisons were made with other specimens, but apparently the series varies only in size from the previously known material. The most noticeable differences, both in the male and the female, are in the length of the tegmina and the caudal femora.

Coloration. In color the species presents an interesting contrast of darks and lights, the base color of whitish gray overlaid with a fuscous to dull black pattern. This pattern consists of dark longitudinal clouds on the head and pronotum and dark distal transverse clouds on all the abdominal tergites with suffusions of darkness on the lateral abdominal tergites. The caudal femora have two, or sometimes a third, transverse dark cloudings which are obsolete on the external face. The tegmina are less contrasted, being gray-brown, with the venation somewhat darker.

Distribution. This species was originally described from the Panamint Valley and Argus Mountains in Inyo County, California. The distribution given by Rehn and Grant (1959b) is "a limited area of Inyo County, California, between the mountains to the east of Owen's Lake (which is now a saline sink) and the western side of the Panamint Range, which borders and overhangs Death Valley on the west", from "elevations of from 1500 to possibly as high as 6900 feet". The five specimens from the Nevada Test Site are the only specimens collected out

Table II. Size variation of *Dracotettix plutonius*.

	Length Body	Depth Body	Length Pronotum	Greatest Breadth Pronotum Dorsum	Greatest Depth Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TA, April 8, 1961	21.8	6.7	7.3	5.4	5.2	8.8	10.0	3.0
♂, Measurements of Rehn and Grant (1961)	18.9-23.3		8.2-9.4	5.3-5.5		9.4-11.2	11.2-11.6	
♀, TCC, March 21, 1961	37.6	9.4	10.7	7.5	7.0	10.4	13.7	3.8
♀, TA, April 16, 1961	41.5	9.8	11.7	7.5	8.1	10.9	14.2	3.7
♀, TA, September 19, 1961	35.1	10.0	11.2	7.7	7.0	11.6	13.2	4.0
♀, Measurements of Rehn and Grant (1961)	34.5-45		11.5-13.2	7.5-8.8		12.3-14.2	15.4-17.0	

of the Inyo County area and the State of California. This locality at the Nevada Test Site now represents the most eastern (and northern) distributional limits known for the species.

Habitats. According to Rehn and Grant (1959b), the species occurs in the "upper part of the Lower Sonoran Life Zone, and probably enters the Upper Sonoran, although we have no definite evidence except known elevations to support the assumption". The authors further state that "little information is available on the exact conditions where *plutonius* has been taken. Apparently . . . it occurs above the *Larrea* belt and below that of juniper and pinyon. No clearly associated vegetational notes are available, but the localities where the species has been taken by others have been visited by the senior author, but unfortunately not at the time when *Dracotettix* has been taken".

Several trips were made into the area where the original discovery was made in March, and extensive collecting by the author produced only one specimen, the female collected on April 16, 1961. The preferred vegetation of the insect at the Nevada Test Site is definitely sagebrush (*Artemisia tridentata*), of what might be considered the Upper Sonoran Zone. Attempts at securing this species by sweeping the brush were futile. It was also useless to try to spot the insect visually. The one specimen obtained by the author was from a shrub that had been inspected visually and then kicked forcefully at the base. It was found that a strong kick at the base of the shrub would be violent enough to remove the other Orthoptera, so this technique was used, finally, in securing the specimen. After being kicked out of the sagebrush it tried to recover to the bush immediately in a series of quick hops, the wings being useless to the large body. The insects apparently rest on the stouter vertical branches where they are almost perfectly concealed by the patches of light and dark bark of the shrub. The feeding habits of the insect are unknown, but from an examination of the area the insect undoubtedly feeds on *Artemisia tridentata*.

The other four specimens in the series were "accidental" discoveries, the insects hopping from the bush when disturbed. Many hours of concentrated efforts by several collectors by visually spotting or sweeping have not produced more than the five specimens.

Seasonal Occurrence. Rehn and Grant (1959b) comment as follows: "clearly a Spring form, all known material of *plutonius* was secured in April and May. Field work in the same areas by the senior author later in the year during the period of greatest heat (August and September), and in three different years, failed to produce the species."

One adult female collected on September 19, 1961, extends the seasonal distribution to at least late summer. It is probably present, though never common, from early spring (the earliest spring record being March 24, 1961) through late summer, or early autumn.

Localities Represented. Specimens examined (adults): 5.

Studies TA and TCC, Midvalley, 2 males, 3 females, from March 24 to April 16 and September 19, all on *Artemisia tridentata*. No immature specimens were collected.

Genus *Tytthotyle* Scudder

1897. *Tytthotyle* Scudder, Canad. Entom., XXIX, p. 74.

Tytthotyle maculata (Bruner)

(Figures 19, 23; Table 12; Map 3)

1889. *Thrinchus* (?)*maculatus* Bruner, Proc. U.S. Nat. Mus., XII, p. 79.

Distinctive Features. This large, fully winged (in both sexes) species is so distinct it should not be confused with any other acridid in the southwest. The body surface is rather smooth, not rugose, although a few minute tubercles are generally present on the metazona of the pronotum. The median carina of the pronotum is faintly evident, the lateral carinae absent. Three transverse sulci are evident on the pronotum, the most anterior sulcus ending on the disk and not continuous on the lobes as are the other two. The metazona is distinctly longer than the prozona. The tegmina and wings are long, well surpassing the apices of the caudal femora.

Morphological Variation. There is considerable morphological variation in this species, as is found in many of the large-bodied acridids. The relative length of the pronotum is especially variable, due to the angulation of the caudal margin of the disk. The surface of the pronotum, as well as the carinations and sulcations of the head, is variable.

Size Variation. As noted in Table 12, variation in size of body and structure is apparent.

Coloration. "The general pattern seen in this species is a multi-maculate overlay of tones of brown of varying density and shade on a base which may range from chalky white through pale yellowish to a light buff, or rarely

Table 12. Size variation of *Tytthotyle maculata*

	Length Body	Length Pronotum	Greatest Breadth Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, CB, Aug. 28, 1959	22.1	6.1		23.8	12.6	3.0
♂, MCC, Aug. 12, 1961	23.5	6.7		25.6	12.8	3.3
♂, JA July 18, 1961	27.1	7.0	5.3	27.1	14.2	3.3
♂, Measurements of Rehn and Grant (1961)	22.0-33.0	5.6-8.8	4.4-6.3	23.6-34.5	12.3-17.8	
♀, 5M, July 24, 1961	32.8	9.5	6.6	34.8	17.6	4.5
♀, 5DA, July 15, 1961	33.7	10.5	7.5	36.6	18.3	4.6
♀, 5M, Sept. 26, 1961	38.9	9.5	6.8	33.4	19.1	4.4
♀, Measurements of Rehn and Grant (1961)	31.0-48.5	9.4-12.4	6.1-8.3	33.9-45.7	18.7-25.6	

even greenish white. Often there is what may be called a wash of 'limestone' bluish gray on the head and pronotum. The internal surface of the caudal femora is in greater part carmine, the ventral sulcus plum purple, the internal face of the caudal tibiae carmine; the wings are very faintly marked with bluish and the apex is very lightly infuscate." (Rehn and Grant, 1961)

In the series from the Nevada Test Site the coloration is variable as quoted above. The tegmina are very maculate, the general color varying from light to dark. The suffusion of bluish gray on the head and pronotum is often encountered and especially noticeable across the dorsal pronotum, extending onto the lateral lobes. The carmine of the caudal femora is reduced to a lesser extent in some specimens.

Distribution. This species is known only from the hottest and most arid sections of the southwest, including southeastern California, southern Nevada, western Arizona and extreme southwestern Utah. It is most frequently encountered in the lowest portions of the Lower Sonoran Life Zone within its range.

"The species is often much localized, probably due to habitat and food preferences not yet fully determined. Altitudinally its occurrence varies, apparently depending on the general conditions of the terrain and probably the temperature. In areas of very high summer temperature it appears to reach higher levels than it does in other sections within its range. In Arizona the highest locality from which we definitely know it is approximately 1600 feet. On the other hand in the desert areas of southern California and Nevada it reaches much higher, 1700 to 4800 feet being known elevations while it has been taken at 255 feet below sea-level at Salt Flat, in Death Valley, California." (Rehn and Grant, 1961)

At the Nevada Test Site it has been found in only a few of the lower areas where it is not common.

Habitats. According to the authors previously quoted (Rehn and Grant, 1961) "the species is known to feed on the creosote bush (*Larrea*) and in a large number of cases has been taken or flushed from this dominant Lower Sonoran shrub . . . . The senior author, who has collected it many times in a number of localities over a period of fifty years, has found it only on *Larrea* (and often feeding on it) or on the ground. On the latter it may be found on or about lava fragments, or on silt and outwash slopes which have no lava. Also it will frequent areas with pebbles and rock fragments other than lava, occasionally these glazed with 'desert varnish'. Sometimes it will be found crouching toad-like on top of a lump of lava. As has been noted by other observers it is a strong flier, and from personal knowledge it is more liable to settle on the sprays of a *Larrea* bush than on the ground. When it does settle on the ground it will crouch and allow a net to pass over it before hurtling into the air and flying off. It has been seen in alighting to crawl between pebbles or even throw itself sidewise into a small crevice, where it laid motionless and was readily picked up by the fingers. On the surface it may be said to be slow and awkward in its movements, but on the wing it exhibits exceptional ability in eluding a pursuer. Also on account of the blending of its coloration in its usual habitats it is difficult to follow with the eye. Clearly *Tytthotyle* appreciates and enjoys heat. It was active in Death Valley in August, 1919, when official shade temperatures were in the neighborhood of 120° F."

The habitat summary above clearly indicates the observations of the author. In collecting

at the Nevada Test Site the species was generally found on vegetation other than *Larrea*, even in areas where *Larrea* was present. In all areas, however, it was characteristic of the so-called "desert pavement", the numerous small rocks scattered about on the surface of the ground. In the recorded captures it was noted that the insect was found at the tips of the shrubs during the hottest part of the day and could best be obtained by capture with the fingers, inasmuch as many of the shrubs upon which it was found were spiny, and sweeping would end in failure of capture.

Seasonal Occurrence. Adults have been recorded as early as April 7 and as late as October 8, with immatures found late in March and into April. At the Nevada Test Site the earliest adult occurrence was June 10, with September 26 representing the latest date. The greatest activity of the species was in August. No nymphs were collected during the course of the study.

Localities Represented. Specimens examined (adults): 9.

Study 5A, 1 specimen, June 10, on ground, in area of *Larrea divaricata*.

Study 5DA, 1 specimen, July 15, in area of *Larrea divaricata*.

Area 5, 2 specimens, July 24 and September 26, vegetation unidentified.

Area 6, 1 specimen, August 15, on *Coleogyne ramosissima*.

Study CB, 1 specimen, August 28, on *C. ramosissima*.

Study MCC, 1 specimen, August 12, vegetation unidentified.

Study JA, 2 specimens, July 18 and August 19, on *Lycium andersonii*.

Subfamily Cyrtacanthacridinae

The species of this subfamily, commonly known as the "spine-breasted" locusts, may be easily recognized by the presence of a conical or cylindrical elevation, termed the prosternal spine, projecting from the prosternum. The face is usually vertical, the head decidedly rounded. The tarsal pulvilli are exceptionally large, a feature correlated with the characteristically plant-loving habitats, and a well-developed arolium is present between the tarsal claws.

These insects are customarily found on vegetation, in sharp contrast to the soil-frequenting habits of most of the other acridids. Although some are decidedly colorful, they are generally drab, less attractively colored, the coloration being generally protective. This coloration is mainly a combination of olivaceous, yellow and brown of varying shades with ornamental touches of reds or blues.

As with the other groups of the Acrididae, in order to present a comprehensive picture of the subfamily, a study of the internal genital structures would be required. Apart from these structures, the most reliable external features are the form of the cercus and other terminal abdominal appendages of the male. In *Melanoplus*, one of the largest of the North American genera of grasshoppers, a knowledge of these structures is absolutely essential. The females of this genus are very difficult to classify owing to the variability of external characters.

The important economic species which are found in cultivated areas and on the ranges are found in this group. Most of the economic species belong to the genus *Melanoplus*. Many are omnivorous, others are selective in food habits, feeding primarily on dicotyledons, especially the perennial members of the plant family Asteraceae. The migrations and plagues of grasshoppers throughout history were primarily due to species belonging to this subfamily.

Because of their seeming preference for cultivated areas or meadows, the subfamily is poorly represented at the Nevada Test Site. This area is well within the distribution of a number of species that may never be found at the test site because of this preference, unless, of course, they are found in migration. This ecological factor undoubtedly explains the absence of such common species as *Schistocerca shoshone* (Thomas), *Melanoplus mexicanus* (Saussure), *M. femur-rubrum* (DeGeer), *M. packardi* Scudder, *M. differentialis nigricans* Cockerell, *M. bivittatus* (Say), and *M. yarrowi* (Thomas).

It is possible that *Ocdaleonotus borckii orientis* Hebard may be found at higher elevations on the Nevada Test Site, but is not included in the key. It would fit the first couplet (with *Melanoplus*), but is distinct from that genus by the presence of distinct lateral keels on the pronotum. The species was described from specimens taken at Lee Canyon, a few miles from the Nevada Test Site.

The key presented is a very artificial one, but will be quite adequate for the few species found in this area. Anyone attempting to utilize the key should be cautioned by the variability, both as to color and as to the development of the wings of individual species.

Key to the Genera of CYRTACANTHACRIDINAE

1. Subgenital plate of male with a distinct subapical tubercle (Fig. 24); body color green (or greenish) or buff, usually with contrasting colors on pronotum or tegmina 2

   Subgenital plate of male without a subapical tubercle (Fig. 25); body color dark, never as above, tegmina and wings variously developed from completely alate to reduced to small nonfunctional pads ..... *Melanoplus* Stål

2. Body variously marked with contrasting red and yellow; tegmina and wings projecting beyond the caudal femora by at least the breadth of the tegmina ..... *Poecilotettix* Scudder

   Body not marked with contrasting red and yellow; tegmina and wings variously developed from short nonfunctional pads to completely alate 3

3. Body bright green (occasionally lighter) with dorsal white stripes on pronotum and white lateral patches on thorax; tegmina bluish-green, with very narrow white stripes ..... *Hesperotettix* Scudder

   Body uniformly colored, buff or tan, without light stripes, or if present never bright green. (There may be a dark median dorsal stripe and postocular stripes on head and pronotum, but not as in alternate.) ..... *Acoloplides* Caudell

FIG. 24

FIG. 25

Figs. 24-25. 24, *Hesperotettix viridis nevadensis*, male, apex of abdomen, lateral view. 25, *Melanoplus complanatipes canonicus*, male, apex of abdomen, lateral view.

Genus *Acoloplides* Caudell

Genus *Acoloplides* Caudell* 1915. *Acoloplides* Caudell, Proc. U.S. Nat. Mus., 49, p. 28.

Key to the Species of *Acoloplides*

(Modified from Wallace, 1955.)

Ventral basal wedge on hind femur of male projecting ventrad for a distance approximately equal to its width at base when viewed laterad (Fig. 26); tegmina equalling or surpassing the abdomen and/or hind femora ..... *A. tenuipennis* (Scudder)

Ventral basal wedge on hind femur of male projecting ventrad for a distance less than its width at base when viewed laterad (Fig. 27); tegmina not reaching the tip of abdomen and/or hind femora, sometimes not much longer than pronotum ..... *A. minor* (Bruner)

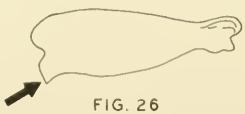


FIG. 26

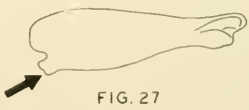


FIG. 27

Figs. 26-27. 26, *Acoloplides tenuipennis*, male, caudal femur, lateral view. 27, *A. minor*, male, caudal femur, lateral view.

*The name *Acoloplides* was proposed by Caudell to replace the name *Acoloplus* of Scudder, now considered to be a synonym of *Melanoplus*. See Wallace, 1955, for the historical development involving the name change.

Aeoloplides tenuipennis (Scudder)
(Figure 26; Table 13; Map 4)

1897. *Aeoloplus tenuipennis* Scudder, Proc. U.S. Nat. Mus., XX, p. 68.

Established Synonomy. *Aeoloplus arizonensis* Scudder; *Aeoloplus oculatus* Scudder.

Distinctive Features. This species, supposedly, has the ventral basal wedge on the hind femora extended more than in *minor*, and the tegmina of both sexes are "almost always" surpassing the tip of the abdomen. Wallace (1955) states that the "ventral basal wedge of hind femur well developed in both sexes, in male usually projecting ventrad for a distance about twice its width at base in lateral view, in female usually projecting about two-thirds of width at base in lateral view". This statement is incorrect, inasmuch as, even in typical forms, the ventral basal wedge projects only approximately equal to the basal width of the wedge. In his illustrations Wallace shows this to be about equal.

Size Variation. The length and breadth of the ventral basal wedge of the caudal femur is difficult to measure. Comparative measurements were made, however, using a standard grid micrometer in a stereoscope. The averages of five male specimens are as follows: length of the ventral basal wedge 0.31 mm; breadth of the ventral basal wedge 0.48 mm. The averages of seven female specimens are as follows: length of the ventral basal wedge 1.78 mm; breath of the ventral basal wedge 0.42 mm.

A comparison of the Nevada Test Site specimens was made with typical *tenuipennis* determined by Wallace and used in his revision of the genus. The specimens compare favorably except in the most important external character, the ventral basal wedge of the caudal femur.

Coloration. The predominant color of this insect is light gray with a yellowish or greenish-yellow tinge, older individuals being darker and brownish. A median dorsal brown stripe extends from the occiput of the head over the pronotum; a light streak, the same as the ground color, is usually present in the center, starting as a fine line at the anterior margin of the pronotum, or occasionally beginning at the transverse incision of the pronotum. A postocular stripe is sometimes faintly indicated on the head and sides of the pronotum. The tegmina are usually light olive-gray, often with small, indefinite dark maculations. The hind femora contain three broad indefinite bands on their external surface; the hind tibiae, in specimens from the Nevada Test Site, are light mauve, this color becoming less intense dorsally and distally.

Table 13. Size variation of *Aeolopides tenuipennis*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 5M, September 26, 1961,		2.9	9.4	6.9	2.2
♂, CM, August 22, 1961	13.3	3.4	10.5	7.5	2.5
♂, CM, August 22, 1961	13.3[5]	3.6	11.9	8.3	2.6
♂, 5E, June 17, 1961	13.7	3.6	12.3	8.2	2.6
♂, 5A, June 20, 1961	14.3	3.8	13.7	8.2	2.7
♂, 5E, July 14 ,1961	14.6[5]	3.1	13.4	7.6	2.8
♂, CM, July 18, 1961	15.0[5]	3.4	11.8	7.5	2.7
♂, Measurements of Wallace (1955)	14.0-28.0	3.4-5.6	10.4-21.5	7.6-12.0	2.5-3.7
♀, CM, August 22, 1961	14.7	3.8	10.7	9.1	2.8
♀, CM, August 10, 1961	15.0	3.9	10.2	8.8	2.8
♀, 5A, June 20, 1961	15.1	4.5	14.9	9.6	2.9
♀, 5M, September 26, 1961	15.2	3.5	11.2	7.9	2.6
♀, CM, July 13, 1961	15.5	3.9	11.7	8.2	2.9
♀, CM, June 17, 1961	15.9	3.9	10.7	9.0	3.0
♀, 5M, September 26, 1961	16.0	3.8	12.1	8.1	2.5
♀, 5M, September 26, 1961	16.1	3.5	10.5	7.8	2.5
♀, Measurements of Wallace (1955)	15.5-24.0	4.2-5.8	11.5-21.0	9.7-13.3	2.8-4.0

[5]Abdomen curved upward.

The nymphs, represented only by later instars from the Nevada Test Site, are often difficult to tell from *Hesperotettix viridis* nymphs, inasmuch as they are often bright green, with or without a pronotal stripe, or more frequently tan, which color phase is also found in nymphs of *Hesperotettix*. It is quite impractical to try to distinguish the nymphs of *tenuipennis* and *minor*.

Additional comments, especially as to comparative features and morphological variation, distribution, habitats, and seasonal occurrence, are given under the discussion of *Acoloplides minor*.

Localities Represented. Specimens examined (nymphs and adults): 36.

Study CM, Cane Springs, 10 nymphs, June 22 to August 22; 9 adults, June 17 to August 22, all on *Atriplex canescens*.

Study 1F, 1 nymph, June 19, on *Salsola kali*.

Area 5, 1 nymph, July 1; 8 adults, June 20 to September 26, vegetation unidentified, but probably on *Atriplex confertifolia*.

Study 5E, 2 nymphs, May 27 to June 15; 4 adults, June 17 to July 14, on *Atriplex confertifolia*.

Area 3, 1 nymph, August 15, on *Atriplex confertifolia*.

Acoloplides minor (Bruner)
(Figure 27; Table 14; Map 4)

1904. *Acoloplus minor* Bruner. Colorado Agricultural Exp. Sta. Bull. 94, pp. 60-61.

Established Synonomy. *Aeoloplus eremiaphila* Hebard.

Comparative Features. Of this species, Wallace (1955) states that it resembles *tenuipennis* but is usually much smaller and the tegmina seldom reach the tip of the abdomen (usually much shorter) and are evenly narrowed to a rounded apex. The following statement is made in its entirety from Wallace's revision of the genus:

"The difficulty encountered in constructing that portion of the key which separates *tenuipennis* from *minor* emphasized the possibility that *minor* is a subspecies of *tenuipennis*. Length of tegmina, the most obvious distinguishing character, is not very satisfactory for diagnosis in this genus. In most of the specimens of *tenuipennis* from Williams in Coconino Co., Arizona, and northward the tegmina reach very slightly short of the tip of the abdomen, though longer tegmina are typical of the species. Specimens of *minor* from Valmey, Nevada, have the tegmina slightly surpassing the tip of the abdomen in the male and nearly that long in the female. In *minor* the length of the tegmina is not clearly correlated with north-south distribution as it is in *tenuipennis*. Specimens of *minor* from Lovelock, Nevada, have the wings sufficiently developed for flight, while those from Wadsworth, 58 miles to the southwest, are brachypterous.

"The difference in the ventral basal wedge of the hind femur, particularly in the male, appears to be dependable (except in the few available specimens of *tenuipennis* from Coconino County, Arizona, some of which have a femoral wedge similar to that of *minor*), but it is a small difference in degree of development. The shape of the prosternal spine will separate most specimens of these two forms (including the Coconino County specimens) but it is somewhat variable and cannot be used as an absolute criterion. The width of the intermetasternal space of the female presents a small difference which is not too dependable. The differences in the phallic structures of the two forms are slight and not dependable, though small but constant differences exist between all of the other species of the genus. Further collecting in the areas of contact of overlap of the ranges of these two forms may demonstrate the regular occurrence of specimens intermediate in all of these characters. The few specimens available from these areas indicate that the two forms are distinct. Specimens of *tenuipennis* from Cima in California, Beatty in Nevada and Zion National Park in Utah are typical of the species while specimens from the adjacent localities Cuchenberry Ranch in California, Spring Mountain in Nevada and Pipe Springs in Arizona are typical of *minor*. The Coconino County population of *tenuipennis* is separated from *minor* by the Grand Canyon so interbreeding cannot occur. In any case, the two forms are certainly distinct enough to be retained as subspecies, even if they should be determined to be conspecific.

"Tinkham (1938, p. 347) referred to '*Acoloplus tenuipennis tenuipennis* Scudder' indicating that he recognized at least two subspecies of *tenuipennis*. Hebard, in notes in the possession of T. H. Hubbell, listed under *Acoloplus* the form '*tenuipennis minor* Bruner 1904' with the uncompleted comment: 'Reduced to race by . . . .' A search of the literature has failed to reveal that *minor* has been reduced to subspecific rank in a publication. Until more material from the areas of contact or overlap of these two forms is studied, it seems best to retain

minor as a distinct species, which, in truth, it may be."

In collecting at the Nevada Test Site, and in a study of the entire collection from that area, I find it difficult to justify conclusive evidence of typical *tenuipennis*. Specimens have been found with long tegmina, surpassing the abdomen by more than their own width, a supposed characteristic of *tenuipennis*. The abdomen as a comparative structure in size, especially in *Acoloplides* males cannot be relied upon as a criterion because of the usual nature of the upturned abdomen, and the possibility of stretching the abdomen in the female.

Size Variation. The averages of the ventral basal wedge of the caudal femur are as follows: three male specimens length 0.2 mm, breadth 0.4 mm; three female specimens, length 0.15 mm, breadth 0.47 mm.

Coloration. The color is very similar in all parts of the insect to *tenuipennis* except that the dark postocular stripes on the head and pronotum are sometimes well defined and of the same color as the median dorsal stripe. The dark spots on the sides of the first two or three abdominal segments are present in about three-fourths of the specimens (according to Wallace). Darker specimens of *minor* are more common than lighter specimens.

Distribution. The distribution of *minor* is given by Wallace as being well restricted to the Great Basin to include extreme southwestern Idaho, southeastern Oregon, northeastern California, and southeastern California across the state line from Las Vegas, Nevada, all of which are within the confines of the Great Basin. According to Wallace's records the only specimens from outside the Great Basin are from Coconino Co., Arizona, near Pipe Springs, and Delta Co., Colorado, at Delta, the type locality!

It is interesting to note that the type locality is so far distant from the Great Basin confines.

Specimens before me, not previously recorded, that seem typical of *minor* are from Washington County, Utah (Shivwits Indian Reservation, September 9, 1959, Andrew H. Barnum and one mile north of St. George, June 10, 1959, Andrew H. Barnum); Sanpete County, Utah (Palisade Park, August 6, 1961, Andrew H. Barnum); Grand County, Utah (Westwater, August 9, 1953, Andrew H. Barnum, and Ruby Canyon, on the Colorado River near Westwater, August 13, 1950, Andrew H. Barnum); and Mesa County, Colorado (Grand Junction, July 26, 1953, and August 12, 1956, Andrew H. Barnum).

The distribution of *tenuipennis*, by contrast, is given by Wallace as being south and east of *minor*, forming a semi-circle in distribution around that form.

Habitats. At the Nevada Test Site, *Acoloplides* is associated with the various species of *Atriplex*. No absolute correlation could be made with reference to the two species. Generally, *A. minor* frequents *Atriplex confertifolia*, but is found with regularity on *Kochia americana* in the *Kochia-Atriplex* association. On the other hand, *A. tenuipennis* is most frequently encountered on *Atriplex canescens*.

The nymphs are easily obtained by sweeping the vegetation, but the agility of the adults makes them more difficult to collect. The adults were never common and could not be obtained in larger series.

The adults are frequently encountered near the ends of the stems of the shrubs, but when disturbed jump into the center of the bush. The best method of collecting, where the insects are

Table 14. Size variation of *Acoloplides minor*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 1G, July 10, 1961	11.6[a]	2.8	5.3	7.4	2.3
♂, 6A, July 12, 1961	12.4	3.3	6.0	7.8	2.3
♂, 1G, July 12, 1961	14.1	2.9	6.7	7.5	2.5
♂, Measurements of Wallace (1955)	11.5-17.5	3.0-4.3	5.5-7.5	7.0-9.1	2.3-2.8
♀, 6A, August 14, 1961	12.7	4.2	7.1	9.4	2.9
♀, 6A, August 16, 1961	14.9	3.8	6.1	8.9	2.7
♀, ECB, August 11, 1961	15.4	3.6	6.8	8.3	2.7
♀, Measurements of Wallace (1955)	13.5-21.0	3.3-5.0	5.3-9.0	7.5-11.0	2.3-3.5

[a]Abdomen curved upward.

so uncommon, is to trample the bush. The specimens are satisfactorily dislodged, but are so wary that they recover to another shrub very quickly. They characteristically jump, but will not hesitate to fly short distances.

Seasonal Occurrence. *Acoloplides* is typically a mid-summer form and no definite correlation could be made between the occurrence of *minor* and *tenuipennis*. Adult *minor* was found only in July and August, whereas *tenuipennis* occurred earlier and later.

Localities Repesented. Specimens examined (nymphs and adults): 22.

Study 6A, 14 nymphs, June 16 to August 16; 3 adults, July 12 to August 16, on both *Atriplex confertifolia* and *Kochia americana*.

Study 1G, 2 nymphs, May 28 and July 19, 2 adults, July 10 and 12, on *Atriplex confertifolia*.

Study ECB, 1 adult, August 11, on *Atriplex canescens*.

Additional Remarks. In a comparison of the total series before me there is little correlation in wing length, a very unreliable character in the Orthoptera, especially in arid areas. There is little correlation in the extension of the ventral basal wedge of the caudal femur, and no correlation in the width of the intermetasternal space of the female. There is only a slight difference in date of appearance and habitat.

The assignments made herein on the basis of all of the above characters may be faulty. The differences noted in morphology may be due to environmental differences. Study 6A, most characteristic of *minor*, is a very arid area of low *Atriplex confertifolia* and *Kochia americana*. These environmental situations are suggestive of smallness of size and shortness of wings.

According to the complete series from the Nevada Test Site which have been assigned to the two species, little reliance can be given to a single character. All of the specimens were at first considered to be *minor*, but on the basis of Wallace's revisionary study, after comparison of this series with specimens in the author's collection from Utah and Colorado, after comparison to original material designated by Wallace in his study, and after considerable hesitation, the present assignments are made.

A comparison of available specimens with those from the test site indicates that subspeciation is present in the *tenuipennis-minor* complex, in which case Tinkham and Hebard were correct in their subspecific assignments, inasmuch as *tenuipennis* has priority. The Nevada Test Site is an area of intergradation.

No types have been studied to confirm these opinions, however, or to test the hypothesis of *minor* being an absolute synonym.

Genus *Hesperotettix* Scudder

1875. *Hesperotettix* Scudder, Bull. U.S. Geol. Surv. Terr., II, p. 262.

Hesperotettix viridis complex

1872. *Caloptenus viridis* Thomas, U.S. Geol. Surv. Rep. Mont. Adj. Terr., p. 450.

Established Synonomy. *Hesperotettix festivus* Scudder.

Distinctive Features. This group, as present at the Nevada Test Site, consists of a single variable species which has been subdivided into a number of different subspecies. The adults are distinctive and should not be confused with any other form from the area. Nymphs, however, may be confused with *Acoloplides*, as certain color phases of *Acoloplides* are suggestive of *Hesperotettix*.

Most of the specimens collected at the Nevada Test Site show an intermediate condition between two typical subspecies. Others are typical of one subspecies. The Nevada Test Site is apparently an area of intergradation where all three forms are found. The group could, conceivably, be discussed as a single, variable species. Subspecific differences can not be distinguished in any immature stage, and such immature specimens are assigned only on the basis of adult collections.

The species can be recognized by the following morphological features and color pattern:

In profile, the face is noticeably slanted, especially in males. The vertex is very narrow between the eyes, but expanded immediately in front of the eyes. The median and lateral carinae of the pronotum are absent, or nearly so, but marked by contrasting colors. The tegmina and wings are variously developed according to the characteristics given in the key to the subspecies. The hind femora are elongate and slender.

Morphological Variation. In its typical condition the species is highly variable in size, brilliancy and intensity of marking, which is largely if not entirely in keeping with the luxurious and green through light yellowish-brown to brown color of the plants on which it lives.

Coloration. A most striking color pattern exists. It is bright green to greenish brown (in older specimens) marked with thin whitish or yellowish longitudinal streaks. The median carina is striped with a whitish line which arises on

Key to the Subspecies of *Hesperotettix viridis*

1. Distal margin of tegmen truncate, subequal to the length of the pronotum (Fig. 28) ..... *H. viridis termius* Hebard

   Distal margin of tegmen acutely produced, never truncate, variable in length from short to long[7] 2

2. Tegmen extending to end of caudal femur, or slightly beyond, its apex broadly rounded (Fig. 29) ..... *H. viridis viridis* (Thomas)

   Tegmen generally short, subequal to the length of pronotum, often considerably longer, its apex pointed (Fig. 30) ..... *H. viridis nevadensis* Morse

FIG. 28

FIG. 29

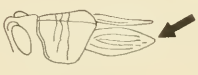


FIG. 30

Figs. 28-30. 28, *Hesperotettix viridis termius*, male, head, pronotum, and tegmina, dorso-lateral view. 29, *H. v. viridis*, male, head, pronotum, and tegmina, dorso-lateral view. 30, *H. v. nevadensis*, male, head, pronotum, and tegmina, dorso-lateral view.

the occiput, bordered on each side with a thinner blackish line, variously developed and often absent, and extending to the posterior margin of the pronotum. A whitish line, sometimes indistinct, arises on the margin of the occiput against the compound eye and continues along the humeral angle of the pronotum, and continues down the humeral angle of the tegmen. A third white line generally extends from the compound eyes across the lateral lobes of the pronotum. The typical specimen is marked with black or dark brown on the lateral lobes of the pronotum between the two light lines. The light coloration is variously developed on the thorax and caudal femora.

The nymphs of the species are generally marked with the single dorsal white line.

Distribution. The species is characteristically a western form, common from the Great Plains to the Pacific Coast. It is recognized as subspecies or geographic varieties throughout its range.

Seasonal Occurrence. Adults are found at the Nevada Test Site concurrently with nymphs from June to September, with the greatest occurrence being in late July and early August.

Hesperotettix viridis viridis (Thomas) (Atypical)

(Figure 29; Table 15; Map 5)

Morphological Variation. This species is not found in the typical condition at the Nevada Test Site, but is intermediate between *viridis* and *nevadensis*. Because some specimens are more representative of *viridis*, the group is included herein.

The intermediate *viridis-nevadensis* forms collected are slightly smaller than typical *viridis* and lack the pink coloration of the hind femora, which color character is typical of the *viridis* condition. The black markings on the lateral lobes of the pronotum are variously developed.

Distribution. Typical *viridis* is absent from most of the desert portions of the southwest, but is widespread, abundant, and generally distri-

Table 15. Size variation of *Hesperotettix viridis viridis*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 3CH, July 22, 1961 (small)	12.3	3.0	10.3	7.4	1.7
♂, 3CH, July 22, 1961 (large)	12.9	3.3	10.8	7.6	1.95
♀, 3CH, July 22, 1961 (small)	14.4	3.9	12.0	9.0	2.2
♀, 3CH, July 22, 1961 (large)	16.4	3.9	13.3	9.7	2.1

[7]The variability of tegminal length is very obvious in the group. This single character is one of the most controversial in the group collected at the Nevada Test Site.

buted over the Great Plains and at higher elevations of the southwest.

These intermediate forms were collected in only one area at the Nevada Test Site, and all nymphs collected here were assigned to this same intermediate group. It is impossible to distinguish any differences between the nymphs collected over the test site, and all other nymphs have been assigned to either *termius* or *nevadensis* on the basis of adult collections.

Localities Represented. Specimens examined (nymphs and adults): 25.

Study 3CH, July 22, on *Chrysothamnus viscidiflorus* and *Tetradymia* sp.

Hesperotettix viridis nevadensis Morse

(Figures 24, 28; Table 16; Map 5)

1903. *Hesperotettix nevadensis* Morse, Psyche, X, p. 115.

Established Synonomy. Hebard in 1931 established *H. gillettei* Brunner as a synonym. *H. cuticipennis* Henderson nec Scudder is also a synonym.

Morphological Variation. Specimens from the Nevada Test Site which have been assigned as typical *nevadensis* show a reduced condition of the tegmina and wings. One typical female was collected *in copula* with an intermediate *nevadensis-termius* male. The present series is indistinguishable from those marked intermediate *viridis-nevadensis* except for the short tegmina and wings which are typically pointed at the apex.

Distribution. According to Hebard (1920a) the present race, in the state of Utah, "supplants *viridis viridis* where aridity has become progressively more decided, and is in turn supplanted by the much more local and less numerous *viridis termius* in the extensive desert areas of large western portions of the state".

If both races are indeed found at the Nevada Test Site the same comments with reference to numbers and distribution apply.

Localities Represented. Specimens examined (nymphs and adults): 19.

Study 6CR, 2 adults, September 19, on *Coleogyne ramosissima* (not a natural host, but probably an accidental occurrence).

Study TA, 13 nymphs and adults, June 23 to August 31, on *Chrysothamnus viscidiflorus.*

Study 3CG, 1 adult, June 27, vegetation not determined.

Study EM, 2 adults, July 24, vegetation not determined, probably *Chrysothamnus viscidiflorus.*

Study CBA, 1 adult, July 18, on *Chrysothamnus viscidiflorus.*

Hesperotettix viridis nevadensis (Atypical)

Two males (measurements given below with *nevadensis*) are considered intermediate between *nevadensis* and *termius*, in each case there being an "in between" condition of the pointed and truncate apex of the tegmina. In one specimen a variability was noticed in each tegmen on the same specimen, one tegmen being typical of each subspecies.

Hesperotettix viridis termius Hebard

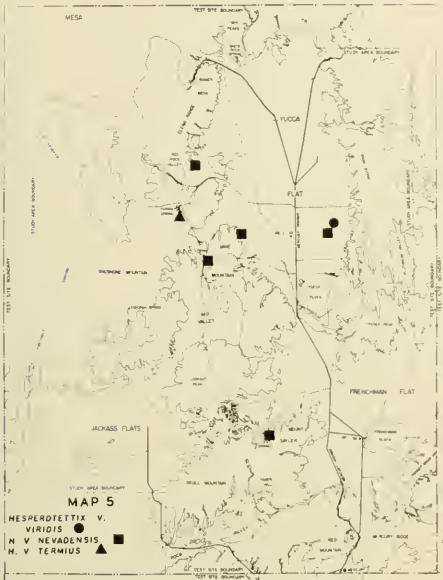
(Figure 30; Table 17; Map 5)

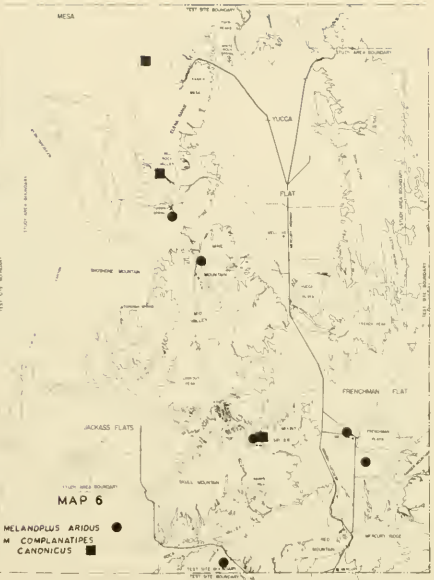
1918. *Hesperotettix nevadensis termius* Hebard, Trans. Amer. Entom. Soc., XLIV, p. 163.

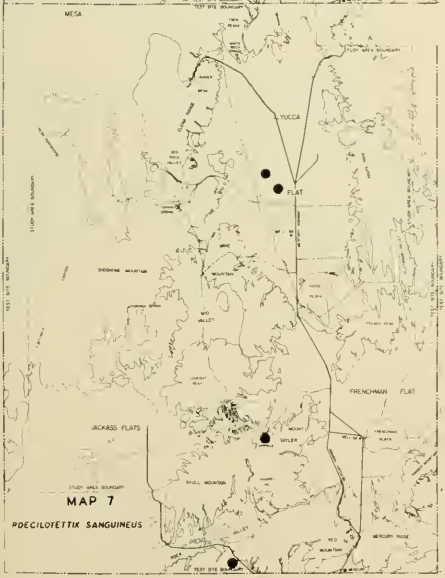
Table 16. Size variation of *Hesperotettix viridis nevadensis.*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6CR, September 19, 1961 (typical)	12.5	2.8	4.5	6.6	1.7
♂, EM, July 24, 1961 (atypical)	12.4	3.1	2.5	7.3	1.9
♂, TA, August 31, 1961 (atypical)*	13.2	3.0	3.1	7.0	1.9
♀, TA, June 23, 1961 (typical)	16.9	4.2	4.7	9.7	2.35
♀, TA, August 31, 1961 (typical)	17.4	4.0	4.9	8.6	2.2
♀, TA, August 31, 1961 (typical)*	17.0	3.8	3.5	8.1	2.2
♀, 6CR, September 19, 1961 (typical)	17.5	4.0	4.4	8.5	2.1

*Specimens *in copula* referred to above.


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 5
HESPEROTETTIX V. VIRIDIS
N. V. NEVADENSIS
H. V. TERMIUS


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 6
MELANOPLUS ARIDUS
M. COMPLANATIPES
CANONICUS


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 7
POECILOTETTIX SANGUINEUS

MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 8
EREMIACRIS PALLIDA

Table 17. Size variation of *Hesperotettix viridis termius*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TCB, July 16, 1961	11.9	2.8	2.5	6.8	1.7
♀, TCB, July 16, 1961	15.7	3.7	4.1	8.7	2.3
♀, TCB, July 16, 1961	19.1	3.7	3.2	9.4	2.4
♀, TCB, June 23, 1961	16.9	4.4	3.5	9.4	2.5

Established Synonomy. This was described as a race of *nevadensis* but was later referred by Hebard to a race of *viridis*. *Hesperotettix pacificus* Henderson nec Scudder is an established synonym.

Distribution. This race was described from Milford, Beaver Co., Utah, but also found at Crestline and Caliente (Lincoln County), Nevada. It was reported as of "arid southern Nevada and California as far west as the Argus Range."

Habitat. The specimens referred to as typical *termius* were collected in foothill-canyon regions at the test site. The series from TCB included one brown phase female adult, all the others being green, but some drying to brownish.

Localities Represented. Specimens examined (nymphs and adults): 14.

Study TCB, July 16, on *Chrysothamnus viscidiflorus* and *Eriogonum fasciculatum*.

Additional Remarks. In certain areas of its distribution, this group is very common and even injurious to vegetation. At the Nevada Test Site, however, it was uncommon. The test site area is apparently a zone of intergradation of the different forms, or the species may be more complex and more variable than to even suggest subspeciation.

Radiation effects on a smaller population could conceivably produce the same results of normal subspeciation as would be shown over the entire range of a species. The extent of reduction or elongation of alar organs and the characteristic termination of the tegmina, then, might be the result of exposure to radioactive substances.

Genus *Melanoplus* Stål

1879. *Melanoplus* Stål, Rec. Orth. I, p. 79.

Key to the species of *Melanoplus*[9]

Tegmen not extending to the tip of the abdomen, in length no longer than the pronotum (Fig. 31); furcula developed feebly, generally no longer than the last dorsal segment from which it arises; cerci of male elongate, only slightly flattened (Fig. 32) ..... *M. aridus* (Scudder)

Tegmen extending to or beyond the tip of the abdomen; furcula well developed, cerci of male broader, grooved, and slightly expanded at apex (Fig. 33) ..... *M. complanatipes canonicus* Scudder

FIG. 31

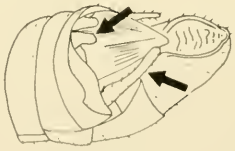


FIG. 32

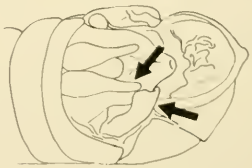


FIG. 33

Figs. 31-33. 31, *Melanoplus aridus*, male, head, pronotum, and tegmina, dorso-lateral view. 32, *M. aridus*, male, apex of abdomen, dorso-lateral view. 33, *complanatipes canonicus*, male, apex of abdomen, dorso-lateral view.

[9] *M. rugglesi* Gurney should be found at the Nevada Test Site, but was not collected. Both solitary and migratory phases occur in the group, indicating the variable extent of development of tegmina and wings. The males can be recognized by the very broad cerci. The females of many species of the genus are difficult to differentiate.

Melanoplus aridus (Scudder)
(Figures 31, 32; Table 18; Map 6)

1879. *Pezotettix aridus* Scudder, Proc. Bost. Soc. Nat. Hist., XX, pp. 84-85.

Distinctive Features. Brachypterous, the tegmina and wings shorter than the pronotum, the tegmina reduced to short oval pads. Antennae of the male conspicuously long. Posterior margin of the pronotum subtruncate. Cerci of male very slender, elongate. Furcula small, bluntly tipped, approximately one-fourth the length of the epiproct.

Coloration. Brownish flavous, marked with black. Head with a narrow mesial black stripe and a broader postocular band, continuous, but generally interrupted on the lateral lobes of the pronotum. Hind tibiae glaucous, changing to bluish gray or brownish in dead specimens.

Distribution. This species is widely distributed throughout the southwest from California to Texas from lower elevations in the Lower Sonoran deserts to high altitudes (the Canadian zone to at least 9400 feet, according to Ball *et al.* 1942). At the Nevada Test Site it was found widely distributed, though uncommon, in Midvalley, at Cane Springs, Jackass approach, and in the Frenchman Flat area.

Habitats. At the test site the species was found on *Artemisia tridentata* and *Coleogyne ramosissima*, the only recorded vegetation. In other areas of distribution it could have been associated with *Larrea divaricata* and vegetation associated with *Grayia-Lycium*.

Seasonal Occurrence. Adults were collected from August 17 to October 15. Only two nymphs were collected, both late instar females, on August 17.

Localities Represented. Specimens examined (nymphs and adults): 10.

Study TA, Midvalley, 2 nymph females, 1 adult male, August 17, on *Artemisia tridentata*.

Study TCB, 1 adult female, October 14, vegetation not recorded, probably on *A. tridentata*.

Study CM, Cane Springs, 1 adult female, September 30, vegetation not recorded.

Study JA, Jackass approach, 1 adult male, 1 adult female, *in copula*, October 15, on *Coleogyne ramosissima*.

Studies 5C and 5M, Frenchman Flat environs, 1 adult male, September 3, 2 adult females, September 26 and October 3, vegetation not recorded.

Additional Remarks. This species is only tentatively referred to *M. aridus*. One male and one female were sent to Dr. Gurney at the U.S. National Museum for confirmation, who extracted the genital complex of the male but found that the tips of the aedeagal valves had been broken off. Therefore, the correct placement could not be made.

This may or may not represent a different species of the *aridus* group or a new species. A further study of the group will have to be made to determine the correct placement.

Melanoplus complanatipes canonicus Scudder
(Figures 21, 25, 33; Table 19; Map 6)

1897. *Melanoplus canonicus* Scudder, Proc. Amer. Phil. Soc., 36: 26, 34.

Distinctive Features. Tegmina and wings moderately slender and gently tapering, extend-

Table 18. Size variation of *Melonaplus aridus*.

	Length Body	Length Pronotum	Length Tegmen	Breadth Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TA, August 17, 1961[10]	15.1	3.5	2.4	1.2	9.0	2.4
♂, 5C, September 3, 1961	12.4	2.7	2.15	0.8	7.8	2.3
♂, JA, October 15, 1961	13.6	2.8	2.1	1.0	7.7	2.1
♀, CM, September 30, 1961	18.7	3.5	2.4	1.2	8.2	2.6
♀, TCB, October 14, 1961	20.2	4.0	3.2	1.3	10.2	2.7
♀, 5M, October 3, 1961[10]	19.3	3.8	2.9	1.4	10.0	2.8
♀, JA, October 15, 1961	20.0	2.6	2.2	1.2	9.9	2.65
♀, 5M, September 26, 1961	18.2	3.5	2.0	1.05	9.0	2.4

[10]Specimens submitted to the U. S. National Museum for comparison.

ing beyond the apices of the hind femora. Caudal margin of pronotum obtuse-angulate, median carina distinct on the metazona, more obsolete on the prozona. Cerci of male slender, narrowing on basal third, the middle third narrower, then expanding to a nearly equal slightly spatulate tip. Furcula of male very broad on basal third, tapering to parallel appendages, two-thirds as long as the epiproct.

Morphological Variation. There is considerable variation in the production of the tegmina beyond the abdomen, especially the females, in the series examined from the Nevada Test Site. It should be re-emphasized that the use of the abdomen as an organ for comparison is questionable because of the stretching or contracting of that organ. A comparison of two extremes showed the 18.3 mm long tegmina projecting 1.1 mm beyond the abdomen and the 21.0 mm long tegmina projecting 4.6 mm beyond the abdomen.

Coloration. Brownish fuscous, sometimes with a ferruginous tinge, more or less feebly flecked with obscure maculations. Postocular black streak extends to pronotal lateral lobes between transverse incisions. Hind femora indistinctly marked by two black bands, strong dorsally, with some red on inner face of caudal femora. Hind tibiae very pale glaucous.

The nymphs are characteristically colored and can be recognized easily by the conspicuously striped pronotum. The median carina is outlined with a light stripe, the lateral carinae are outlined with dark stripes which extend onto the head.

Distribution. This species, described from the Grand Canyon of Arizona, is common in the sagebrush areas of the Great Basin Desert. It is frequently associated with the vegetation on and near sand dunes.

Habitat. This group was known early in the literature as a sagebrush inhabitant. In this environment the gray and rusty colors harmonize with its surroundings making it extremely difficult to detect when at rest.

It was found in only two areas at the Nevada Test Site, both having a different environment. It was common, though not abundant, in the sand dune area, where it was collected only after persistence because of its remarkable ability of flight and escape. The other habitat was in the very heavy vegetation (*Rumex*) at Cane Springs, where it was quite common but difficult to collect because of its escape into the tall cattails when disturbed.

LaRivers (1948) gave some details of the habits and habitats that compare favorably with observations from the test site: "In addition to sagebrush I have taken it on *Chrysothamnus, Oryzopsis hymenoides, Dalea polyadenia* and several other unidentified succulent sand dune plants. While it has a considerable distribution in sagebrush areas, I have found it in swarming conditions only in the vicinity of sanded regions, particularly active dunes. When disturbed, *complanatipes* flies to on adjacent bush or plant, making it non-stop if the distance is only a matter of a few feet; if the distance is greater, the insect usually alights on the ground and almost immediately flies off again to sanctuary long before the collector can get within disturbing range again. At several sand dune localities, large series could be obtained by merely sweeping a net rapidly in front of the collector while walking through the insects." It might be noted that nowhere at the Nevada Test Site was the race that numerous.

Table 19. Size variation of *Melanoplus complanatipes canonicus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, ECA, September 30, 1961	19.6	4.0	18.5	11.4	2.9
♂, CM, July 13, 1961	19.9	4.5	21.0	11.7	2.9
♂, CM, July 15, 1961	20.5	4.2	18.3	11.1	2.8
♂, CM, July 15, 1961	20.9	4.1	20.7	11.5	2.8
♂, CM, July 15, 1961	23.4	4.8	22.1	11.9	3.0
♀, ECA, September 30, 1961	25.7	4.9	20.7	13.1	3.0
♀, CM, July 18, 1961	26.3	6.1	25.2	14.6	3.6
♀, CM, July 18, 1961	28.0	5.8	24.0	14.3	3.7

Seasonal Occurrence. The earliest occurrence of the insect was May 27 (nymphs). Adults were found from June through October 14. Nymphal instars were found as late as August. The insect is most abundant during August and September.

Localities Represented. Specimens examined (nymphs and adults): 71.

Study 12CF, Kowich Valley approach, 3 specimens, August 12 and August 21, on *Artemisia tridentata*.

Study ECA, sand dunes, 35 specimens from August 11 to October 14, on the various plants growing on the sand dunes.

Study CM, Cane Springs, 33 specimens, from May 27 (nymph) to August 22 (late instar nymphs and adults), on *Rumex* sp. and *Typha domingensis*.

Genus *Poecilotettix* Scudder

1897. *Poecilotettix* Scudder, Proc. U. S. Nat. Mus., XX, pp. 385-386.

Poecilotettix sanguineus Scudder
(Table 20; Map 7)

1897. *Poecilottettix sanguineus* Scudder, Proc. U. S. Nat. Mus., XX, pp. 387-389.

Established Synonomy. This species is also recognized as *P. longipennis* (Townsend) (= *Dactylotum longipennis* Townsend).

Distinctive Features. The species shows a general relationship to *Melanoplus*, but can be distinguished not only by the bright colors but morphologically by the tuberculate abdomen. In this respect it resembles *Hesperotettix*, which genus has a subapical tubercle. In *Poecilotettix* the tubercle is apical. The prosternal spine is very slender.

Coloration. This beautiful, long-winged species will not be confused with anything else on the Nevada Test Site. The general body color is yellow to olivaceous, the long tegmina pale greenish, and the posterior tibiae dark bluish green. The body is conspicuously marked with contrasting red, one median line on the head and along the median carina of the pronotum; the posterior margins of the lateral lobes of the pronotum are outlined in red. Large red spots are present at the humeral angles of the pronotum, variously arranged on the head and on the femora. The metazona of the pronotum is conspicuously punctate with black spots, especially noticeable in the females.

Distribution. This species is an inhabitant of the southwest, being found in the Lower and Upper Sonoran life zones of California, Nevada, Utah, and Arizona. The type locality is Bradshaw Mountain, Arizona.

At the Nevada Test Site it was found widely distributed at lower elevations and was collected from four areas.

Habitats. In keeping with the colors of the insect, green vegetation is the characteristic habitat of the species. It was recorded from *Hymenoclea salsola*, *Coleogyne ramosissima*, *Chrysothamnus viscidiflorus*, and *Ephedra viridis*. *C. ramosissima* is the only non-green shrub listed. No preferred vegetation could be determined because of the uncommon occurrence of the species at the test site.

Seasonal Occurrence. The earliest collecting date for adults was June 19; the latest September 8. No nymphs were collected.

Localities Represented. Specimens examined (adults): 10.

Study 1G, 5 adults, June 19 and July 10, on *C. viscidiflorus* and *E. viridis*.

Table 20. Size variation of *Poecilotettix sanguineus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, JA, July 18, 1961	16.7	3.0	15.1	8.2	2.0
♂, JA, July 18, 1961	17.3	3.3	16.5	8.3	2.4
♂, 1G, July 10, 1961	17.6	3.4	15.7	8.7	2.1
♀, 1G, July 10, 1961	24.5	4.6	21.6	11.0	2.8
♀, 4A, August 11, 1961	25.8	4.9	23.3	11.8	2.8
♀, CM, August 3, 1961	26.1	4.6	21.8	11.0	2.8

Study 4A, 1 adult, August 11, on *H. salsola*.

Study JA, Jackass approach, 3 adults, July 18 and September 8, on *C. ramosissima*.

Study CM, Cane Springs, 1 adult, August 3, on *H. salsola*.

Subfamily Acridinae

This subfamily, as now recognized, includes Acridinae (or Tryxalinae), the so-called "slant-faced locusts," and the Oedipodinae, the "band-winged locusts." These two groups were until recently considered as distinct subfamilies, distinguished on the basis, primarily, of the characters of the head, the face in lateral view slanting or sub-perpendicular, a characteristic that has always lead to confusion in trying to separate the genera; the characters of the pronotum, the presence or absence of distinct median and lateral carinae, while reliable for most genera, fail completely as a criterion in some; the intercalary vein of the tegmen, used as a characteristic, leads to difficulties. The coloration of the wings, and all other characters have been useless in the absolute separation of some genera.

The recent emphasis of the internal genital structures has proved the close relationships and has led to the grouping of these two subfamilies under one, the Acridinae.

As now recognized, the subfamily includes a great variety of species showing a diverse external morphology, and includes the majority of the species from the Nevada Test Site. These are the conspicuous grasshoppers of every-day occurrence. They are well represented in a desert environment and are common everywhere.

Although general and specific collecting has been rather extensive at the test site only two-thirds of the expected species have been found. In addition to those species reported here as definite records and included in the keys, the following species may be found that are not included:

Orphulella compta Scudder, a form of the Lower Sonoran life zone, although found commonly in moist areas, should be present along some of the foothills, and higher grassy areas; *Aulocara elliotti* (Thomas) common in short grass over much of its range; *Dissosteira spurcata* Saussure; *Trepidulus rosaceus* (Scudder), previously collected in the vicinity of Las Vegas, Nevada; *Conozoa sulcifrons sulcifrons* (Scudder) and *Conozoa wallula* (Scudder); *Circotettix crotalum* Rehn, described from Lee Canyon, Nevada, perhaps present at higher elevations at the test site; *Cratypedes neglectus* (Thomas) should be found at some of the higher elevations; *Xeracris minimus* (Scudder), one of the smallest acridids; *Coniana snowi* Caudell, found only on sand dunes or in the vicinity of dunes; *Cannula pellucida* (Scudder), while not a desert species, may be encountered at some of the higher elevations.

Key to the Genera of Acridinae

1. Face strongly receding so that the vertex is angled sharply with the front of the face (Fig. 34), to the extent that the lateral foveolae of the vertex are invisible dorsad (Fig. 35) 2

   Face more or less vertical, the vertex broadly rounded into the face (Fig. 36), the lateral foveolae of the vertex, if present, visible dorsad (Fig. 37) 5

2. Antennae ensiform; lateral carinae of pronotum parallel or subparallel (Fig. 38) *Eremiacris* Hebard Antennae simple, if slightly flattened the lateral carinae of pronotum curved 3

3. Head distinctly elevated above pronotum which is strongly sellate (Fig. 39) *Bootettix* Bruner Head not distinctly elevated above pronotum which is flat or nearly so 4

4. Lateral carinae of pronotum parallel or subparallel; antennae simple; fastigium of vertex with surface largely convex, lacking a conspicuous infra-marginal impression (Fig. 35) ..... *Amphitornus* McNeill

   Lateral carinae of pronotum well indicated in color, divergent in middle of pronotum; antennae subensiform; fastigium of vertex with surface largely concave, with a conspicuous infra-marginal impression (Fig. 40) ..... *Cordillacris* Rehn

5. Hind wings not brightly colored, never marked with a conspicuous black band; median carina of pronotum not strongly elevated 6

   Hind wings brightly colored, red, yellow or blue, and/or marked with a conspicuous black band; median carina of pronotum variously elevated, low to strongly carinate 10

6. Internal apical spines of caudal tibiae unequal in length (Fig. 41); lateral foveolae of the vertex well marked on all sides (Fig. 42) 7

Internal apical spines of caudal tibiae subequal in length; lateral foveolae of the vertex not well indicated 9

7. Costal field of the tegmen broadly expanded by one series (in males) or by two series (in females) of enlarged hyaline cells (Fig. 43) ..... *Ligurotettix* McNeill

Costal field of the tegmen not broadly expanded as in alternate 8

8. Lateral carinae of pronotum continuous and sharply constricted in middle; prozona shorter than metazona (Figs. 36, 37) ..... *Psoloessa* Scudder

Lateral carinae obsolete on prozona (Fig. 42); prozona longer than metazona ..... *Ageneotettix* McNeill

FIG. 34

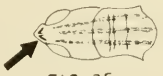


FIG. 35

FIG. 36

FIG. 37

FIG. 38

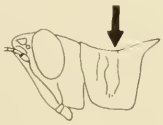


FIG. 39

FIG. 40

FIG. 41

FIG. 42

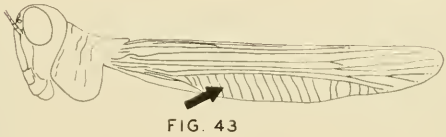


FIG. 43

Figs. 34-43. 34, *Amphitornus coloradus ornatus*, male, head and pronotum, lateral view. 35, *A. c. ornatus*, male, head and pronotum, dorsal view. 36, *Psoloessa delicatula delicatula*, male, head and pronotum, lateral view. 37, *P. d. delicatula*, male, head and pronotum, dorsal view. 38, *Eremiacris pallida*, male, head and pronotum, dorsal view. 39, *Bootettix punctatus*, male, head and pronotum, lateral view. 40, *Cordillacris occipitalis cinerea*, male, head and pronotum, dorsal view. 41, *Ligurotettix coquillcti cantator*, male, distal tibia and tarsus of caudal appendage showing internal apical spines, lateral view. 42, *Ageneotettix deorum deorum*, male, head and pronotum, dorso-lateral view. 43, *L. c. cantator*, male, head, pronotum, and tegmen, lateral view.

9. Occiput with a series of transverse carinae medio-caudad of compound eyes, the fastigial impression elongate in both sexes; metazona of pronotum not greatly expanded (Fig. 44) ..... *Cibolacris* Hebard

Occiput with a series of transverse carinae medio-caudal of compound eyes, the fastigial impression broadly rounded in both sexes; metazona of pronotum conspicuously enlarged, much wider than prozona (Fig. 45) ..... *Anconia* Scudder

10. Interspace of metasternum linear, or distinctly longer than broad in male, narrower than interspace between the mesosternal lobes in female (Fig. 46); median carina of pronotum distinct, intersected by one transverse incision (Fig. 47) ..... *Arphia* Stål

Interspace of metasternum broad, quadrate in male, transverse in female (Fig. 48) 11

11. Median carina of pronotum intersected by two sulci, the anterior one of which is shallow; lateral carinae long and intersected by the posterior sulcus (figs. 49, 50, 51, 52); form robust 12

    Median carina of pronotum intersected by two nearly equal sulci; lateral carinae of pronotum distinct or not intersected by the posterior sulcus (Fig. 53); form slender 13

12. Median carina of pronotum conspicuous and well elevated (figs. 49, 51); wing disk red ..... *Xanthippus* Saussure

    Median carina of pronotum slight (figs. 50, 52); wing disk blue ..... *Leprus* Saussure

13. Lateral lobes of pronotum acutely produced (Fig. 53) ..... *Mestobregma* Scudder

    Lateral lobes of pronotum rounded (figs. 54, 55), a small tooth may be present on lower lateral lobes (Fig. 56) 14

14. Lateral prominences present near median carina of pronotum, more pronounced in male (figs. 54, 57) ..... *Derotmema* Scudder

    Disk of pronotum without high lateral prominences near median carina (figs. 55, 56) ..... *Trimerotropis* Stål

FIG. 44

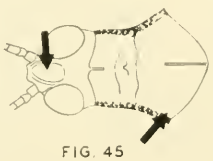


FIG. 45

FIG. 46

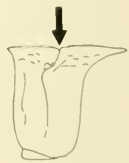


FIG. 47

FIG. 48

FIG. 49

FIG. 50

FIG. 51

FIG. 52

FIG. 53

FIG. 54

FIG. 55

FIG. 56

FIG. 57

Figs. 44-57. 44, *Cibolacris parviceps* aridus, male, head and pronotum, dorsal view. 45, *Anconia integra*, male, head and pronotum, dorsal view. 46, *Arphia conspersa*, male, metasternum and proximal abdominal sternites, ventral view. 47, *A. conspersa*, male, pronotum, lateral view. 48, *Trimerotropis pallidipennis pallidipennis*, male, metasternum and proximal abdominal sternites, ventral view. 49, *Xanthippus corallipes*, male, pronotum, lateral view. 50. *Leprus glaucipennis*, male, pronotum, lateral view. 51, *X. c. corallipes*, male, pronotum, dorsal view. 52, *L. glaucipennis*, male, pronotum, dorsal view. 53, *Mestobregma impexum*, male, pronotum, lateral view. 54, *Derotmema delicatulum*, male, pronotum, lateral view. 55, *T. p. pallidipennis*, female, pronotum, lateral view. 56, *T. strenua*, male, pronotum, lateral view. 57, *D. delicatulum*, male, pronotum, dorsal view.

Genus *Eremiacris* Hebard

1929. *Eremiacris* Hebard, Proc. Acad. Nat. Sci., Phila., 81:303-425.

Eremiacris pallida (Bruner)

(Figure 38; Table 21; Map 8)

Distinctive Features. A species of slender form, small to medium in size, with the head strongly slanted. The wings are variously developed, generally reaching to the end of the abdomen. A poorly developed prosternal spine is present, which character led to the placement of the genus in the subfamily Cyrtacanthacridinae until recent years when a study of the genital characters showed a true relationship of the group.

Coloration. The degree of color variation in the species leads to the assumption that perhaps two or three species are actually found in the area. The color of the insect ranges from light tan or decidedly yellowish and yellowish-green through darker. These different color phases to some extent may be correlated with vegetation upon which the insect lives. Most of the specimens show a marking of lateral bars on the head and pronotum, which markings are suppressed in the yellowish and greenish specimens. An occasional uniform yellow or uniform light green is encountered, and yellowish tegmina on a uniform light green body is found. In some of the light brownish specimens there is a suffusion of white on the head, on the pronotum and on the caudal appendages. All of the nymphs collected showed a definite pallid coloration. The darker colors are apparently found only in the adult specimens.

Nearly all of the specimens collected at the Nevada Test Site were of the light, yellowish-green phase; about twenty percent were of the darker phase. Although there was no consistency of color in the areas collected, the specimens do vary according to habitats. In the sagebrush area the insects tend to be more gray or brown; those insects collected in and among grasses were rather consistently light. Some of the intermediate areas, between the two extremes showed both phases.

Distribution. This species is widely distributed throughout the southwest. Its known range extends from north central New Mexico west to California. At the Nevada Test Site it is one of the more common species and has a wide distribution.

Habitats. The species is most often associated with *Oryzopsis hymenoides*. It is very active and a strong jumper, especially in the nymphal stage, and is most difficult to collect, not only because of its agility but because of its coloration. It readily escapes in vegetation where it is well hidden. Or if it happens to alight on the ground it is well concealed because of its resemblance to the small bleached desert sticks and twigs.

In the Cane Springs area the insect was most common on *Elymus cinereus* and *Distichlis strictus*, the common grasses.

Seasonal Occurrence. Nymphs of *Eremiacris* were collected from May 13 (where they were common in study area 1BF) to mid-August (as sub-adults). Adults were collected in early June and were present to October 4. They were most common and numerous during July, and are a summer insect at the test site. Their numbers are maintained throughout the hottest months.

Localities Represented. Specimens examined (nymphs and adults): 112.

Study TA, Midvalley, 22 nymphs and adults, June 22 to September 19 (most common in August at this higher station), on *Oryzopsis hymenoides*.

Table 21. Size variation of *Eremiacris pallida*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TA, August 17, 1961	17.6	2.8	12.1	8.1	1.4
♂, CM, August 10, 1961	18.4	2.8	12.9	8.0	1.5
♂, CM, July 15, 1961	19.1	2.9	12.8	8.3	1.5
♀, ECA, August 12, 1961	26.6	4.3	17.6	11.2	1.9
♀, TA, August 17, 1961	27.3	4.3	18.1	11.3	2.0
♀, CM, August 22, 1961	31.3	4.6	20.5	12.6	2.3

Study 3CD, 4 nymphs, June 27, on *O. hymenoides*.

Study 6CL, 5 adults, July 13 and 14, on *Bromus tectorum*.

Study 5A, 1 adult, August 31, vegetation unrecorded.

Studies CM and CB, at Cane Springs, 38 nymphs and adults, May 27 to August 10, on *E. cinereus* and *D. strictus*.

Miscellaneous *Grayia-Lycium* studies (1B, 1G, etc.), 10 nymphs and adults, May 13 to August 17, on *O. hymenoides*.

Miscellaneous mixed vegetation studies (JA, ECA, ECH, ACC, TCB), 32 nymphs and adults, June 6 to October 4, vegetation, where recorded, *O. hymenoides*.

Genus *Bootettix* Bruner

1889. *Bootettix* Bruner, Proc. U. S. Nat. Mus., XII, p. 57.

Bootettix punctatus (Scudder)

(Figure 39; Table 22; Map 9)

1890. *Gymnes punctatus* Scudder, Psyche, V, p. 440.

Distinctive Features. This insect is one which shows a strong slant to the face. A distinct angle is formed with the vertex, and the lateral foveolae form a right or acute angle with the plane of the fastigium. The head is distinctly elevated above the saddle-shaped pronotum. The antennae are short and simple (filiform). The coloration is the most distinctive feature.

Coloration. This is one of the most interesting insects found in the southwestern United States. It has an unusual rich green coloration with silvery white or mother-of-pearl markings in addition to brown and black on the pronotum, pleura and limbs. The tegmina have small black dots. An occasional brownish specimen is found. These two extremes (green and brown) correlate to the *Larrea divaricata*, upon which it is always found. This shrub varies from a deep green to brown. (See additional remarks under "Habitats".)

Distribution. This insect is found wherever *Larrea* grows in the Lower Sonoran life zone of the southwest. At the Nevada Test Site the species was collected wherever the shrub was present, and was collected, even, in some areas where the shrubs are very scattered, not at all common.

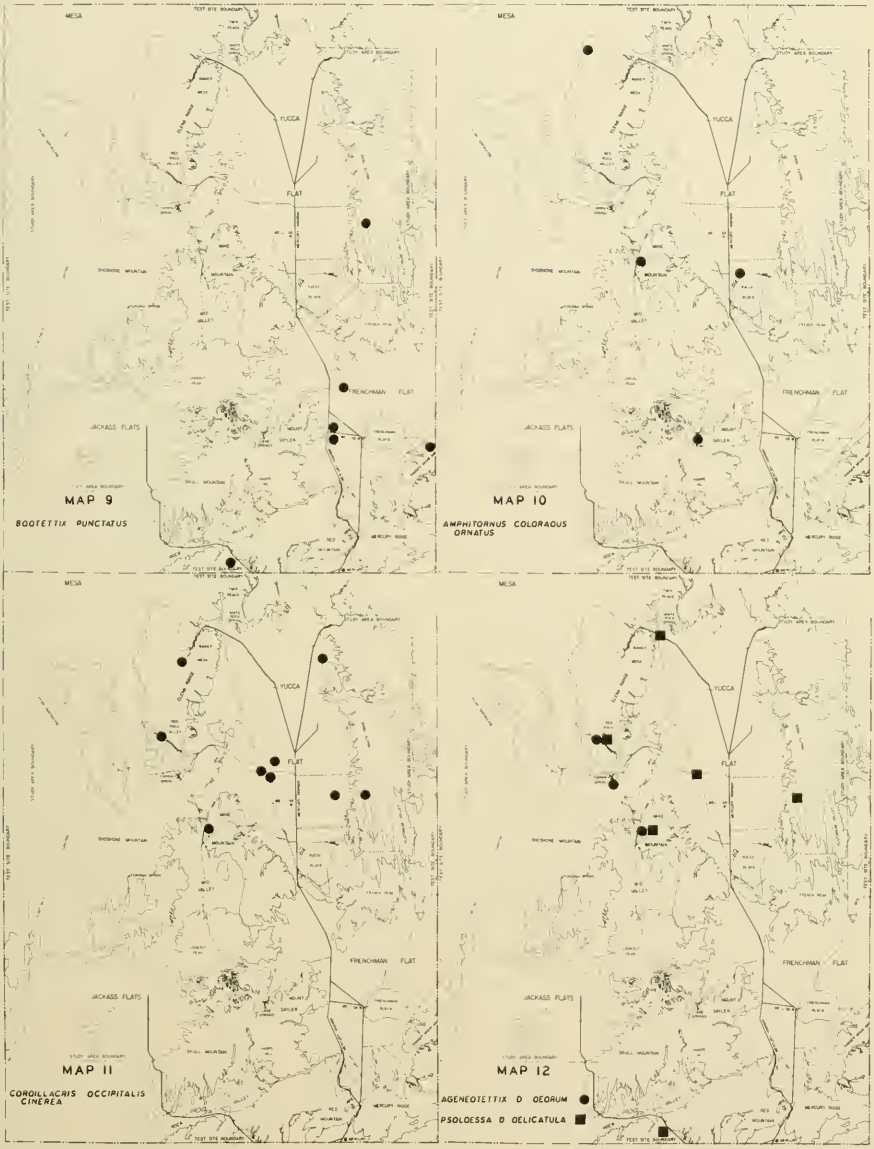
It is completely restricted in habitat to the creosote bush and the distribution is about equal to that of the host plant within the borders of the United States.

Habitats. Recognition is difficult because of the rich olive-green base color which blends so completely with the foliage of the creosote bush. The markings produce the effect of the silvery sheen of the seed capsules of the shrub. This is one of the few species of insects strictly limited to one shrub, and shares with *Insara covilleae* as being one of the two orthopterans found only on *Larrea*.

Larrea achieves a very deep green and dense growth under optimum conditions, especially along the margins of roads where it receives more moisture than its neighbors away from the road. At the Nevada Test Site, as with other areas of the arid west, its growth is very stunted and it takes on a brownish foliage. *Bootettix* most commonly frequents the dense growth, but is also found on stunted, brown shrubs in few numbers. Collecting indicated that the majority of specimens taken in the dense, deep green shrubs were predominantly of the green phase; in the areas where the shrub was more brown the incidence of the brown phase in the insects

Table 22. Size variation of *Bootettix punctatus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 5CQ, July 13, 1961	14.6	2.5	14.0	8.3	2.0
♂, 5A, August 16, 1961	15.3	2.8	14.0	8.4	1.8
♂, 5CQ, July 13, 1961	15.8	2.8	13.6	8.3	2.0
♀, 5A, July 14, 1961	20.3	3.6	15.4	10.1	2.2
♀, 5A, August 16, 1961	20.8	3.7	14.4	10.7	2.2
♀, 5CQ, July 13, 1961	21.1	3.5	13.5	10.7	2.2


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 9
BOOTETTIX PUNCTATUS
MAP 10
AMPHITORNUS COLORADUS ORNATUS
MAP 11
CORDILLACRIS OCCIPITALIS CINEREA
MAP 12
AGENEOTETTIX D OEORUM
PSOLOESSA D OELICATULA

was very high, pointing out the value of protective coloration as an advantage to the insect.

The species is most commonly collected by sweeping the outer branches with a net. By actual comparison, very few specimens were visually spotted in collecting before sweeping was resorted to, in some instances several minutes of close observation were required to spot a group of specimens. They characteristically rest at the tips of the branches on the upper side and will frequently not even move when touched with the finger. The insect is a very excellent jumper and a good flyer and if removed from the shrub to the ground will very quickly regain the protective confines of the shrub, either by flight or a series of quick jumps.

The nymphs are easy to recognize as of that species, inasmuch as they are colored like the adults, but are also difficult to spot and collect except by sweeping the branches.

The stridulation of the males is distinct.

Seasonal Occurrence. The insect is a summer species. The earliest occurrence was June 15 (nymphs) and the latest date of collection of adults was October 22. Adults occurred early in July, while nymphs were present into August. The greatest activity of the insect was during July and August.

Localities Represented. Specimens examined (nymphs and adults): 320.

Area 5 (5A, 5CQ, 5HP), Frenchman Flat, 280 nymphs and adults, June 15 to October 22.

Study 3CD, 16 adults, June 27 to August 15.

Studies JA (Jackass Approach) and CB (Cane Springs), 23 nymphs and adults, June 24 to October 15.

Study ACC, 1 adult, October 2.

Genus *Amphitornus* McNeill

1897. *Amphitornus* McNeill, Proc. Davenport Acad. Nat. Sci., VI, p. 223.

Amphitornus coloradus ornatus McNeill

(Figures 34, 35; Table 23; Map 10)

1897. *Amphitornus ornatus* McNeill, Proc. Davenport Acad. Nat. Sci., VI, pp 224-225.

Established Synonomy. *Acentetus unicolor* McNeill; *Acentetus carinatus* Scudder; *Stenobothrus bicolor* Thomas.

Distinctive Features. The vertex of the head is a little declivent, advanced in front of the eyes, the antennae are slightly flattened. The pronotal disk is well rounded and the lateral carinae are extremely faint and not interfering with the rounded outline of the humeral angles. The median carina is distinct and accompanied by more or less distinct supplementary carinae on the disk. All of these carinae are intersected by the posterior principal sulcus only a little or considerably behind the middle. The posterior angle of the disk is moderately rounded. The tegmina are well developed.

Coloration. The insect is dull brown with fine yellow bars on the sides of the pronotum. A dorsal light stripe may be present on the pronotum and, if present, generally extends onto the head. Two black bars are present on the outer face of the hind femora. The posterior tibiae are bluish.

Distribution. This race is widely distributed throughout western North America, in the Lower Sonoran, Upper Sonoran and Transition life zones. At the Nevada Test Site its distribution was limited by the grasses with which it is associated and it was uncommon in all collecting areas.

Habitats. *Amphitornus* was found in some of the same situations as *Eremiacris*, with which it should not be confused because of its different appearance and different habits. *Amphitornus* seeks the denser grass and tries to

Table 23. Size variation of *Amphitornus coloradus ornatus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6CL, July 13, 1961	15.7	2.8	12.7	7.7	2.4
♂, CM, August 22, 1961	17.2	3.6	14.5	9.6	2.1
♂, TA, September 19, 1961	17.8	3.1	13.7	9.5	2.2
♀, 12CF, August 12, 1961	23.2	4.1	17.2	12.8	2.7
♀, 12CF, August 21, 1961	24.0	4.3	17.3	13.1	3.0
♀, CM, August 22, 1961	26.0	4.2	18.3	12.8	3.0

escape by concealment in the bunches instead of trying to escape by movement. The insect loses its caudal legs very readily when picked up and care must be exercised in collecting good specimens. The insect was most common on *Distichlis strictus* (at Cane Springs), *Elymus cinereus* (at the approach to Kowich Valley) and *Oryzopsis hymenoides* (in Midvalley).

Seasonal Occurrence. No accurate seasonal occurrence can be given for this group because of the few numbers collected. The earliest adults were collected, however, on July 13; the latest on September 19. No nymphs were collected.

Localities Represented. Specimens examined (adults): 16.

Study 6CL, 1 adult, July 13, no record of the vegetation with which it was associated. The area is very rocky.

Study 12CF, the approach to Kowich Valley, 4 adults, August 12, on *Elymus cinereus*.

Study TA, Midvalley, 4 adults, September 19, on *Oryzopsis hymenoides*.

Study CM, Cane Springs, 7 adults, August 22, on *Distichlis strictus*.

Genus *Cordillacris* Rehn

1901. *Cordillacris* Rehn, Canad. Ent., XXXIII, p. 271.

Cordillacris occipitalis cinerea (Bruner)

(Figure 40; Table 24; Map 11)

1889. *Ochrilidia* (?)*cinerea* Bruner, Proc. U. S. Nat. Mus., XII, p. 52.

Established Synonomy. *Cordillacris affinis* Morse.

Distinctive Features. A slender insect with slanting head and subensiform antennae. The lateral carinae of the pronotum are well indicated in color, but obsolete or subobsolete in contour. A distinctive feature of the group is the conspicuous infra-marginal impression (concave surface) of the fastigium of the vertex. The tegmina and wings reach to the end of the abdomen.

Coloration. This insect is buff colored with brown markings. A dark brown stripe extends from the posterior margin of the eye, widening on the sides of the genae to the anterior edge of the pronotum, then continuing across the pronotum to encompass the upper lateral lobes. Immediately below on the head and lateral lobes of the pronotum is a cinereous area, the cinereous repeating on the lower half of the caudal femur. These markings are bent abruptly inward on the disk of the pronotum. The tegmina have dark brown and cinereous spots, giving the insect a grizzled appearance. The posterior tibiae are testaceous.

Nymphs are easily recognized by the pronotal markings, the ensiform antennae and the projection of the vertex. In these markings it could be confused only with *Psoloessa delicatula delicatula* (Scudder), the only other species of the Nevada Test Site with similar markings, but the groups can be recognized by the projection of the head.

One male and two females (from studies TA, 1BF and 12E) have a less maculate appearance, but with a dark brown stripe extending down the tegmen half its length. Except for the color patterns the entire series is quite consistent. The caudal tibiae are testaceous, except in about half the males which have a pinkish cast.

Distribution. This race is widely distributed throughout the Great Basin and east to the Colorado Rockies and Arizona. It was common in most of the studies maintained at the test site.

Habitats. The species is found only in areas of short grass, especially *Oryzopsis hymenoides*, where it is well concealed. It is a fairly strong

Table 24. Size variation of *Cordillacris occipitalis cinerea*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, ECA, July 30, 1961	15.0	2.6	12.2	9.4	1.8
♂, 1G, July 12, 1961	16.2	2.6	12.3	9.1	1.8
♂, ECA, August 12, 1961	16.8	2.8	13.4	9.9	1.9
♀, 12E, June 16, 1961	20.5	3.4	15.5	11.9	2.1
♀, TA, August 17, 1961	21.5	3.6	15.7	11.7	2.5
♀, ECA, June 22, 1961	22.6	3.6	17.3	11.9	2.2

flyer and active jumper and when disturbed will leave the spot to remain concealed in its new location. It is difficult to collect because of its habits and markings.

Seasonal Occurrence. Adults have been collected as early as May 13 and as late as August 31. The greatest activity is in June.

Localities Represented. Specimens examined (nymphs and adults): 58.

Studies 1G, 1F and 1B, 28 specimens, May 13 to July 12, on *O. hymenoides.*

Study 3CG, 1 specimen, June 27, on *Bromus tectorum.*

Area 3, miscellaneous collecting, 1 specimen, July 15, vegetation not recorded.

Study 10D, 1 specimen, June 14, on *O. hymenoides.*

Study 12E, Rainier Mesa, 1 specimen, June 26, vegetation not recorded.

Study ECA, near sand dunes, 5 specimens, June 27 to August 12, on *O. hymenoides.*

Study TA, Midvalley, 21 specimens, June 22 to August 31, on *O. hymenoides.*

Genus *Agencotettix* McNeill

1897. *Agencotettix* McNeill, Psyche, VIII, p. 71.

Agencotettix deorum deorum (Scudder)

(Figure 42; Table 25; Map 12)

1876. *Chrysochraon deorum* Scudder, Bull. Geol. Geogr. Surv. Terr., II, p. 262.

Established Synonomy. *Aulocara scudderi* Bruner; *Agencotettix occidentalis* Bruner; *Agencotettix arenosus* Hancock.

Distinctive Features. This species is short, rather stout, the male distinctly smaller than the female. The face is nearly vertical and rounded at the vertex. The distinct median carina of the pronotum is continuous, though low, and intersected by one sulcus. The lateral carinae are obsolete on the prozona, which is longer than the metazona.

Coloration. The general color is dull brown above, yellowish-white below, the tegmina brown or grayish-brown, usually with numerous small darker brown quadrate spots, these sometimes confined to a median row. The sides of the head and pronotum have black bars or spots. The caudal tibiae are bright coral red, with a white or lightened proximal ring. The antennae are conspicuously white or light colored.

Distribution. The insect has a wide distribution throughout the entire west, from the Great Plains and north central states to the west, and from Canada to Texas. At the Nevada Test Site it was found only in the intermediate valleys of the Upper Sonoran life zone and into the lower Transition life zone.

Habitats. This is one of the most important range and grassland grasshoppers in the west, where it appears abundantly in some areas. It feeds on grasses and other low plants. It is probably more abundant at the Nevada Test Site than the records indicate. It is difficult to collect unless it appears in large numbers, because of its rapid movement, small size, and concealing pattern by which it blends with the desert vegetation. It is found on the ground where it is exceedingly difficult to detect. It is only associated with *Oryzopsis hymenoides.*

Seasonal Occurrence. *Agencotettix* has a summer appearance. It was first collected on July 16 and the collection date extended to September 30.

Localities Represented. Specimens examined (adults): 8.

Table 25. Size variation of *Agencotettix deorum deorum.*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TA, August 31, 1961	13.3	2.4	9.1	8.8	2.7
♂, TCB, July 16, 1961	13.5	2.5	10.0	8.9	2.6
♂, TCB, July 16, 1961	14.0	2.6	9.6	9.0	2.6
♀, TA, August 31, 1961	16.4	3.1	11.2	11.0	3.0
♀, ECA, September 4, 1961	17.7	3.1	11.7	11.2	3.1
♀, ECA, September 30, 1961	17.9	3.1	11.1	11.1	3.15
♀, TA, August 17, 1961	18.2	3.1	12.2	11.0	3.1

Study ECA, sand dunes, 2 adults, September 4 to September 30.

Study TA, Midvalley, 3 adults, August 17 to August 31.

Study TCB, near Midvalley, 3 adults, July 16.

Genus *Psoloessa* Scudder

1875. *Psoloessa* Scudder, Proc. Boston Soc. Nat. Hist., XVII, p. 512.

Psoloessa delicatula delicatula (Scudder)

(Figures 36, 37; Table 26; Map 12)

1876. *Scyllina delicatula* Scudder, Bull. U. S. Geol. Surv., II, p. 263.

Established Synonomy. *Psoloessa coloradensis* Thomas; *Stirapleura decussata* Scudder; *Stirapleura tenuicarina* Scudder; *Psoloessa* (?) *eurotiae* Bruner.

Distinctive Features. This insect closely resembles *Ageneotettix*, but can be distinguished by its larger size and the color of the caudal tibiae. In *Psoloessa* the tibiae are pink with no sharp demarcation of white on the proximal end. It further differs from that insect by the continuous lateral carinae of the pronotum which are sharply constricted in the middle, making the prozona shorter than the metazona.

Coloration. In coloration and pattern this insect most closely resembles *Cordillacris*. It should not be confused with that insect, however, because of the nearly rounded vertex. *Cordillacris* is typically slant-faced. The dorsal abdomen under the wings is bright, colored the same as the caudal legs. The distinct markings and maculations are very contrasting. One female, perhaps a teneral specimen, had very bright markings. Rehn (1942) has published at length to show the size and color variants of this form.

Distribution. *Psoloessa* shares nearly the same distribution as *Ageneotettix*, from the Great Plains westward. It has a wide distribution over the Nevada Test Site.

Habitats. This species is found on the ground associated with *Oryzopsis*, *Haplopappus*, and probably other perennial plants. It is a very active jumper and is well concealed on the ground among the desert debris. When disturbed it generally flies into or near the shrub or grass.

Seasonal Occurrence. The species appears early in the spring and remains throughout the summer. The first specimen was collected on April 15, the last on September 30. Its most abundant occurrence was in May. No specimens were collected during the month of July, and no nymphs were collected during the course of the study, so there is no indication of whether or not the August and September specimens were from a second brood.

Localities Represented. Specimens examined (adults): 24.

Study 1B, 15 adults, April 15 to June 21, associated with *Oryzopsis hymenoides* and *Haplopappus* sp.

Study 3CD, 1 adult, June 27, vegetation not recorded.

Area 12, Rainier Mesa, 1 adult, June 26, vegetation not recorded.

Study ECA, sand dunes, 2 adults, September 30, vegetation not recorded, probably *O. hymenoides*.

Study JA, Jackass Approach, 1 adult, August 31, vegetation not recorded.

Study TA, Midvalley, 4 adults, June 22 to August 31, apparently associated with *O. hymenoides*.

Table 26. Size variation of *Psoloessa delicatula delicatula*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 1BF27, May 13, 1961	14.2	2.5	13.4	8.8	2.45
♂, 1BF30, May 13, 1961	14.4	2.6	13.9	9.1	2.6
♀, 1BF25, May 13, 1961	24.4	4.0	19.5	13.4	3.7
♀, 1BF25, May 13, 1961	25.6	4.3	20.7	13.2	3.7

Genus *Ligurotettix* McNeill

1897. *Ligurotettix* McNeill, Proc. Davenport Acad. Sci., VI, pp. 198, 257.

Ligurotettix coquilletti cantator Rehn

(Figures 41, 43; Table 27; Map 13)

1923. *Ligurotettix coquilletti cantator* Rehn, Trans. Amer. Entom. Soc., XLIX, p. 64.

Distinctive Features. Lateral foveolae of the fastigium deeply impressed, trapezoidal in shape; antennae short; eyes prominent, occiput higher than disk of pronotum; median carina slight but distinct, intersected near the middle by the principal sulcus; lateral carinae obsolete; prosternum furnished with a large pyramidal spine; scapular area of tegmina greatly expanded, one-third the width of the tegmina, hyaline, with strong, curved oblique veins, forming an efficient organ for the production of sound.

Coloration. The body of the insect is brown, the tegmina gray suffused with brown, the caudal femora with two black bands and dark geniculars lobes. The caudal tibiae are gray. The insect is well concealed in its habitat, on the leafless branches of the xerophytic shrubs.

Distribution. This insect is typical of the western Nevada areas, extending into the higher parts of Death Valley and the Inyo regions of California. The type locality is Mason, Lyon Co., Nevada. The insect was very common during the summer in all lower areas at the Nevada Test Site, and could be heard during the hottest hours of the day. The present series have not been compared with typical material, so may be atypical toward *kunzei*. The drawings and descriptions presented by Rehn (1923) show the insect is more typical of *cantator*.

According to the notes with the original description, this subspecies is found typically in the Upper Sonoran life zone. At the Nevada Test Site, again, it was more numerous in the Lower Sonoran life zone.

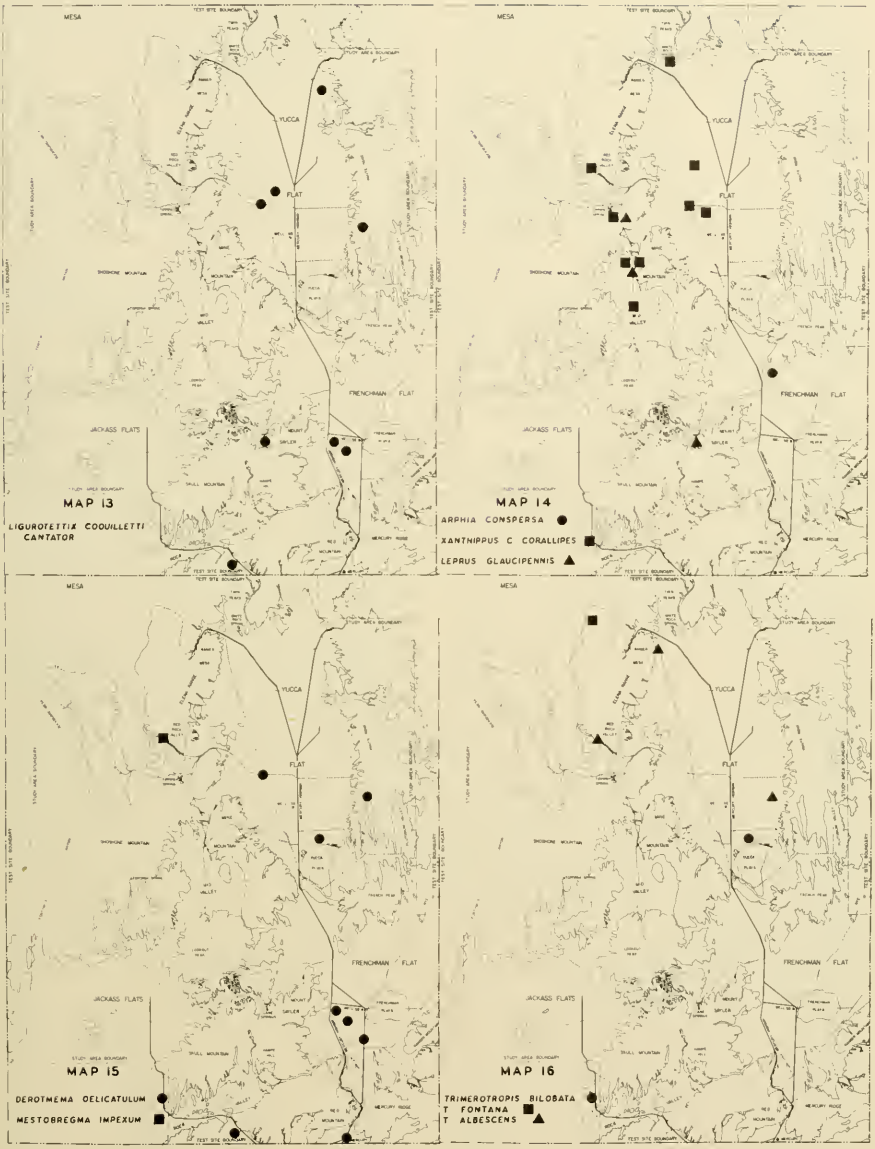
Habitats. The most obvious character about this insect is its ability to produce sound. It is, in fact, very noisy but difficult to see in the shrubs. In order to study the habits of the insect some were visually spotted and captured by hand. The insect is not characteristically strong and any disturbance results in its jumping into the center of the shrub. It generally rests on the outer limbs.

Many of the desert shrubs drop their leaves during the hot summer, and *Ligurotettix* was especially common upon these shrubs. It was found on *Larrea* and other leaved shrubs, but not to any great extent, comparatively. Sweeping for these insects is not successful because of the spiny nature of the shrubs. To collect a series it was found that the best method was to completely trample the shrub, working systematically around the periphery first because the insects nearly always hop into the center branches. By the time the shrub is completely broken down most of the insects have tried to escape to another shrub, where they can be captured if spotted.

The notes of Rehn (1923) on the biology of the group are interesting. "The scattered gray green bush of the Nevada Basin, a land of broad desert plains and valleys and long mountain ranges, is the favored habitat of this subspecies. In the Great Basin greasewood (*Sarcobatus*), in *Atriplex*, and other species of the wiry and spiny shrubs which sparsely clothe the valleys and lower mountain slopes of this region, it will be found at home. In but two places (Daylight Spring and Hole-in-the-Rock Spring) was it found on creosote bush (*Covillea*) [now *Larrea*] which is so much favored by the other subspecies, which is readily understood when it is

Table 27. Size variation of *Ligurotettix coquilletti cantator*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 1C, July 10, 1961	11.8	2.1	11.9	6.9	1.9
♂, JA, July 15, 1961	13.2	2.5	12.2	7.3	2.1
♂, CM, September 30, 1961	13.8	2.6	12.2	7.35	2.1
♀, JA, July 13, 1961	18.1	3.1	15.2	8.5	2.4
♀, 5A, August 3, 1961	18.9	3.3	16.0	9.2	2.5
♀, JA, July 13, 1961	19.3	3.6	16.7	8.9	2.6


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 13
LIGUROTETTIX COQUILLETTI
CANTATOR
MAP 14
ARPHIA CONSPERSA
XANTHIPPUS C CORALLIPES
LEPRUS GLAUCIPENNIS
MAP 15
DEROTMEMA DELICATULUM
MESTOBREGMA IMPEXUM
MAP 16
TRIMEROTROPIS BILOBATA
T FONTANA
T ALBESCENS

realized that this plant is almost absent from the area occupied by true *cantator*. Intermediates between *cantator* and the other subspecies frequently occur on creosote bush. This subspecies was noted by Hebard as stridulating after dark, the two specimens from Fernley, Nevada, being taken by stalking their sound well after night had fallen. Many others were stridulating at the same time in the brush of a *Sarcobatus* flat, and as long as the air remained warm and still they continued their performance. On the passing of a shower accompanied by a cool wind the entire assemblage ceased stridulating and nothing further was heard."

Seasonal Occurrence. The earliest collection was made on June 20, the latest on September 30. Because of the numbers present at that time it undoubtedly is a part of the fauna well into October, at least. It was about equally numerous during July, August and September. No nymphs were collected.

Localities Represented. Specimens examined (adults): 88. (This number represents only the collected specimens. Actually the insect is very common and present in large numbers, according to the stridulations. An actual estimate of numbers is difficult to make.)

Area 1 (studies 1B and 1C), 14 adults, June 24 to September 4, on *Grayia spinosa*, *Lycium pallidum* and *L. andersonii*. Other vegetation not recorded.

Study 3CD, 2 adults, August 15, on *Larrea divaricata*.

Study 5A, 11 adults, June 20 to August 31, on *L. divaricata*.

Study 5E, 12 adults, June 24 to September 2, on *Lycium pallidum* and *Dalea polyadenia*.

Study 10D, 2 adults, August 14 and 16, on *Coleogyne ramosissima*.

Study CM, Cane Springs, 17 adults, September 30, on *G. spinosa*, *C. ramosissima* and *L. pallidum*, principally.

Study JA, Jackass Approach, 30 adults, July 13 to September 3, on *C. ramosissima*, *L. andersonii* and *L. divaricata*. Other vegetation not recorded.

Genus *Arphia* Stål

1873. *Arphia* Stål, Recensio Orthopterorum, I, pp. 113, 119.

Arphia conspersa Scudder

(Figures 46, 47; Table 28; Map 14)

1875. *Arphia conspersa* Scudder, Proc. Boston Soc. Nat. Hist., XVII, pp. 514-515.

Established Synonomy. *Arphia arcta* Scudder; *Arphia frigida* Scudder; *Arphia infernalis* Saussure; *Arphia teporata* Scudder; *Arphia canora* Rehn.

Distinctive Features. This is the first of the so-called "band-winged" grasshoppers found in the area and so common throughout the southwest. The best characteristic to differentiate this species from the other orthopterans with brightly-colored wings is the condition of the metasternal interspace. In *Arphia* this is distinctly linear (longer than broad) in the male and narrower than the interspace between the metasternal lobes in the female. The pronotum is carinate, with one incision.

Morphological Variation. This is a very variable species as is indicated by the above synonomy. Hebard (1937) published at length on the phases of *conspersa*, and established five phases, each with a geographic distribution. Each phase is subject to decided individual variation, and shows such a remarkable response to conditions of the immediate environment "that its extremes are often quite as widely different as any of the typical representatives of the other phases. Moreover, in some cases, one phase fades into another gradually over a wide extent of territory. For these reasons, though it long seemed possible that some valid races existed, I do not feel justified in recognizing any geographic races whatever in the case of *conspersa*."

Table 28. Size variation of *Arphia conspersa*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 5M, July 14, 1961	19.8	4.5	20.8	11.6	3.6
♂, 5M, July 13, 1961	20.4	4.3	20.6	10.8	3.3
♂, 5M, July 14, 1961	20.9	4.3	22.5	11.8	3.6

Coloration. From the Nevada Test Site the insect is dark grayish brown, mottled with darker brown and black. Most of the specimens exhibit a pale dorsal stripe on the tegmina (this condition is variable in the series). The hind wings are red[11] with a black outer band, the spur of the black band extending well inward to the base of the wing. Between the spur and the apex is an area of dark veins and lighter cells, with the apex infumate, slightly lighter than the dark band. The ventral sulcus of the interior femur is bluish, the hind tibiae bluish with a pale basal annulus.

Distribution. This species has a very wide distribution, ranging from Alaska to Mexico and from Texas to Nevada. It was found in only one area at the Nevada Test Site.

Habitats. *Arphia* was collected at or near the top of one of the mountains between Frenchman and Yucca flats. It was found in an area of sparse grasses and small shrubs, typical of its habits and habitats. It is a fairly strong flyer and is deceptive, trying to hide after flight. Three biologists were unable to collect any females after extensive collecting. The females are, however, more sluggish and remain hidden. It is quite possible that the females appear at a different time than the males. No nymphs were found.

Seasonal Occurrence. The only collection dates of the insect were July 13 and July 14. The insect has been collected by the author in similar habitats from May to July, however.

Localities Represented. Specimens examined (adults): 6.

Area 5, south end of French Peak, 6 adult males, July 13 and 14, not found on vegetation and the only observation of vegetation from the area was *Bromus tectorum*.

Additional Remarks. This insect has not been reported from Nevada previously and is assigned here pending complete revision of the genus. It is identical to one specimen in the author's collection from Las Vegas, Clark Co., Nevada, and is slightly atypical to a series of specimens from several localities in Washington County, Utah. The bluish hind tibiae with the pale basal annuli agree with those specimens from Utah, and are very much like a series of specimens from southern Arizona, supposedly *Arphia aberrans* Bruner. A series of *conspersa* from north and east in Utah and from Colorado show a variable condition of the tibiae, ranging (in dry specimens) from very light blue to yellowish. The condition of the tibiae of the Nevada Test Site specimens is suggestive of *Arphia ramona* Rehn from California, but that insect, represented in the author's collection by specimens from Riverside County, California, and one female from Baja California, is quite different morphologically from the present series.

These insects suggest a close relationship of *conspersa* and *aberrans* and the present series is assigned to *conspersa* after much consideration.

Arphia behrensi Saussure has been reported from Nevada by Baker, Essig and LaRivers (in Ormsby County). I have not seen this supposedly yellow-winged species, so have made no comparison of it with the series from the test site.

Genus *Xanthippus* Saussure

1884. *Xanthippus* Saussure, Mem. Soc. Geneve, XXVIII, pp. 46, 88.

Xanthippus corallipes corallipes (Haldeman)

(Figures 49, 51; Table 29; Map 14)

1853. *OEdipoda corallipes* Haldeman, Appendix C in Stansbury, Exploration of Great Salt Lake, p. 371, Pl. X, Fig. 2.

Established Synonomy. *OEdipoda paradoxa* Thomas; *Hippiscus* (*Xanthippus*) *conspicuus* Scudder; *Hippiscus* (*Xanthippus*) *maculatus* Scudder; *Hippiscus* (*Xanthippus*) *eremitus* Scudder.

Distinctive Features. This large, ponderous grasshopper is easily recognized by its very large size (especially the females) and markings. It is the largest acridid found at the Nevada Test Site and is very robust in appearance. The pronotum is enlarged, extending over the occiput approaching the eyes. The head and pronotum are very rugose, the median carina of the pronotum partially obliterated. The tegmina and wings extend beyond the abdomen.

Morphological Variation. This species is very variable over its entire range, and has been grouped into eight or nine subspecies throughout its distribution. The specimens from the Nevada Test Site are very typical of those from the Salt Lake Valley, the type locality.

[11]Authors have used Ridgway (1912) as a means of identifying color of specimens. The book, however, is difficult to obtain for comparative purposes.

Table 29. Size variation of *Xanthippus corallipes corallipes*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TCC, March 22, 1961	26.7	6.5	28.5	14.3	3.9
♂, 1BF26, May 28, 1961	27.2	6.4	28.6	13.6	4.0
♂, 1BF22, May 28, 1961	28.9	6.5	29.0	13.3	4.2
♀, TCB, July 16, 1961	43.8	10.2	40.7	20.4	6.1
♀, 1BF21, May 28, 1961	44.6	10.1	41.7	21.0	6.1
♀, 1BF20, April 15, 1961	53.8	12.2	45.0	24.1	6.7

Coloration. Brown, with dark and light markings on the head and pronotum, the lateral carinae of the pronotum, especially, marked with a lighter color, giving the insect a general "X" pattern on the disk of the pronotum. The tegmina have conspicuous large dark spots, larger medially, smaller and somewhat indistinct distally, the humeral angle marked with a yellowish line, with the area to the posterior being largely darkened. The posterior femora are marked with dark, the internal femora in females almost solid bright coral, the inner margins of the caudal tibiae coral, the outer margins yellowish. In the males the internal face of the caudal femora show three indistinct dark cross bands, the coral color less pronounced, and both the inner and outer margins of the caudal tibiae coral, the color less intense than in females. On the outer surface only the proximal tibiae are more yellowish.

The very large nymphs show the characteristic pronotal markings of the adult, the "X" pattern on the disk of the pronotum being even more recognizable than in the adults.

Distribution. This species is widely distributed throughout the Great Plains area to the west. The subspecies *corallipes* is found from Utah and Nevada south through Arizona, New Mexico and into Mexico. At the Nevada Test Site it is well distributed over most of the area.

Habitats. Both adults and nymphs were very common in early spring to mid-summer, in open areas. The few specimens found on vegetation had apparently crawled onto the shrubs to escape the intense desert heat. The females characteristically hid in *Oryzopsis hymenoides*, where present, but no vegetation was determined upon which the insect fed.

In one burned area (Midvalley, April 16, 1961) specimens were very numerous, especially along the road, representing a population of at least one specimen per square yard throughout the entire large burn.

The nymphs and females are exceedingly easy to collect because of their ponderous size and slow movements, the females flying for only short distances and never far off the ground. The males are strong and active flyers.

This is undoubtedly the most conspicuous, although not the most abundant nor widespread, acridid on the test site.

Seasonal Occurrence. Nymphs were collected as early as January 8 and were present into April. The earliest adult occurrence was March 13, the latest July 16. The latest record is from a higher elevation, in Midvalley, where the insect is apparently able to survive for nearly a month longer than in the intense heat of the lower elevations. It was most abundant during April, decreasing sharply in numbers in May.

Localities Represented. Specimens examined (nymphs and adults): 112. (This represents a small percentage of the total number of specimens observed.)

Study 1BF, 17 specimens, March 13 to May 28, in a *Grayia-Lycium* area. Most of the specimens were collected just beyond the fringe of vegetation eradication due to the effects of the atomic blast, in an area of desert shrubs and scattered bunch grass (*Oryzopsis hymenoides*).

Study 1F, 3 adults, June 19 to 21. The only vegetation in this area was *Salsola kali*, a pioneer species due to complete eradication of vegetation as a result of the nuclear explosion.

Area 4, miscellaneous collecting, 7 specimens, March 13.

Area 12, miscellaneous collecting, 1 specimen, March 16.

Study ECH, 3 nymphs, January 8 to April 1.

Studies TA, TCB, TCC, all Midvalley area, 81 specimens, March 14 to July 16.

Genus *Leprus* Saussure

1861. *Leprus* Saussure, Revue et Magasin de Zoologie, 2e Ser., XIII, p. 398.

Leprus glaucipennis Scudder

(Figures 50, 52; Table 30; Map 14)

1900. *Leprus glaucipennis* Scudder, Psyche, IX, pp. 75-76.

Distinctive Features. Morphologically this species most nearly resembles *Xanthippus* but is distinct because of the slight median carina of the pronotum, not elevated as in *Xanthippus*. The species is generally not as robust as that species. The pronotum is very rugose.

Coloration. The species is easy to recognize in flight because of the bright blue wings. Collected specimens can further be recognized by the prominent dark spots on the tegmina.

There is considerable variation in the series from the Nevada Test Site. The head of some specimens shows a definite ash-gray color, other specimens are darker. The pronotum is variable from light to very dark (one female) and even a reddish suffusion in some specimens. The basal ground color of the tegmina is of the same general color as the pronotum (except the one dark female) to the first dark tegminal bar, which extends across the entire tegmen; the next light space is lighter. The second dark bar is present only anterior to the median vein. The next distinct arca, exceedingly light, is followed by a series of dark spots on a light background, the dark decreasing in intensity to the tip of the tegmen. Some specimens show less obvious banding on the tegmina, the dark areas practically continuous with each other. There is a light yellowish line extending along the humeral angle of the tegmen. The caudal femur has one conspicuous preapical dark band, variously darkened with two other bands on some specimens. The posterior tibia is dull with a light subproximal area. The dorsal tergites of the abdomen (especially in the males) are washed with blue. The inner face of the caudal femur is blue with one large basal and one preapical black band.

The hind wings are light blue to deep blue with a very broad black band and a dark spot at the apex of the wing.

Distribution. The species is distributed from southern California, Nevada, and Arizona south into Mexico. At the Nevada Test Site it was found only at intermediate elevations in two general areas.

Habitats. *Leprus* is uncommon on the test site, but the somewhat robust size and sluggish movements make them easy to capture once they fly. Until they do fly they blend well with the background. The typical habitat upon which they are found is one of small to medium sized rocks among sparse vegetation in the canyons of foothills. None was found directly associated with vegetation.

Seasonal Occurrence. The species was collected from June 22 to September 19. It was most common during the month of August. Two subadults were collected in July.

Localities Represented. Specimens examined (subadults and adults): 22.

Study CM, Cane Springs, 1 adult, September 2.

Studies TA and TCB, Midvalley area, 21 subadults and adults, June 22 to September 19.

Additional Remarks. This series from the Nevada Test Site is very variable in size and color, less variable in morphology, and is assigned to *glaucipennis* pending a complete revision of the

Table 30. Size variation of *Leprus glaucipennis*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, TA, August 31, 1961	19.1	5.2	22.8	10.9	3.2
♂, CM, September 2, 1961	20.5	5.6	23.3	12.0	3.6
♂, TA, August 17, 1961	22.7	5.6	23.3	12.3	3.7
♂, TCB, July 16, 1961	22.0	6.5	26.4	13.8	4.0
♀, TA, July 19, 1961	29.9	8.3	33.2	17.0	5.0
♀, TA, August 17, 1961	32.6	7.2	28.8	15.5	4.5
♀, TA, August 17, 1961	32.3	8.0	31.8	16.5	5.0
♀, TCB, August 7, 1961	32.2	8.1	33.7	17.1	5.1

genus. Typical specimens have greenish-blue hind wings (hence the name), and the specimens from this area would have to be atypical of that species on the basis of wing color.

The species was at first considered to be *L. interior* Bruner, to which it is closely related, if not synonymous.

Genus *Derotmema* Scudder

1876. *Derotmema* Scudder, Appendix H9 of Appendix JJ of Ann. Rep. Chief Eng. U. S. Geogr. Surv. W. 100th Merid., p. 513.

Derotmema delicatulum (Scudder)

(Figures 54, 57; Table 31; Map 15)

1900. *Derotmema delicatulum* Scudder, Proc. Amer. Acad. Arts & Sci., XXXV, p. 390.

Distinctive Features. This small sized, very active insect can be recognized by the enlarged head and prominent eyes. The pronotal disk has prominent rugae and lateral prominences near the median carina. It is less rugose than is typical in the genus, the females being less rugose than the males. The posterior angle of the metazona is broadly rounded or slightly angulate in some specimens. The tegmina and wings are variously produced, always reaching beyond the abdomen, excessively so in some specimens of both sexes.

The nymphs can be recognized by the very large eyes and rugose pronotum.

Coloration. The insect is pallid testaceous, flecked more or less with fuscous and with no distinct banding on the tegmina. A series of dark spots on the proximal tegmen adjacent to the metazona gives the pronotum an elongated appearance. The hind wings have a light yellow disk and a variable black band. The posterior tibiae are light, generally grayish. The antennae are pallid, interrupted with fuscous.

Distribution. The general range of the insect, as listed by Rehn and Hebard (1908) is the "Mohave and Yuma deserts, ranging from the western edge of the Mohave at Mohave and Lancaster, California, to at least Sentinel, Maricopa County, Arizona." It was uncommon at many of the stations at lower elevations in both Frenchman and Yucca flats and adjacent areas.

Habitats. The most common habitat for the species at the Nevada Test Site was the *Atriplex-Kochia* vegetation on the margins of Yucca Playa. It has not been associated with vegetation, inasmuch as the insect is found on bare ground and it attempts to escape by flight rather than to escape into the vegetation. This is one of the few orthopterans collected around lights at night, in the Mercury Area.

Seasonal Occurrence. The earliest record of nymphs of *Derotmema* is June 21, with adults occurring July 3. The last series of adults were collected on September 4. Nymphs were present only into July. It was equally abundant in July and August.

Localities Represented. Specimens examined (nymphs and adults): 36.

Study 1B, 4 adults, September 4; the dominant vegetation in the area was *Grayia-Lycium.*

Study 3CD, 3 adults, August 15, no record of vegetation around which the insects were found.

Study 5A, Frenchman Flat, 5 adults, July 3 to August 10. The vegetation was practically all *Larrea divaricata*, but, of course, the insects were not determined to be associated with the vegetation.

Study 5E, 2 adults, July 13 and August 17, no record of vegetation associated with the specimens.

Study 6A, on the margins of Yucca Playa, 14 nymphs and adults, June 21 to August 16.

Table 31. Size variation of *Derotmema delicatulum.*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6A, July 10, 1961	12.3	2.6	14.8	8.6	1.9
♂, 5E, July 3, 1961	12.9	2.4	16.3	9.2	1.8
♂, 6A, July 12, 1961	15.1	2.8	15.1	8.7	2.1
♀, MD, July 15, 1961	19.4	3.2	20.3	10.4	2.2
♀, 5E, July 13, 1961	20.1	3.8	21.0	10.5	2.4
♀, 5M, July 20, 1961	21.4	4.1	22.2	10.8	2.8

Study JA, Jackass Approach, 7 adults, July 15 to August 22, no record of vegetation.

Mercury, 1 adult, July 15, attracted to lights at night.

Genus *Mestobregma* Scudder

1876. *Mestobregma* Scudder, Hayden's Bull. U.S. Geol. & Geogr. Surv., II, p. 264.

Mestobregma impexum Rehn

(Figure 53; Table 32; Map 15)

1919. *Mestobregma impexum* Rehn, Trans. Amer. Entom. Soc., XLV, pp. 239-242, Plate XXVI, figs. 9 and 10; Plate XXVIII, figs. 13 and 14.

Distinctive Features. Size medium, form slender. The median carina of the pronotum is intersected by two nearly equal sulci, the carina is elevated and bilobate on the prozona, reduced on the metazona. There are accessory projections on either side of the median carina in the middle of the pronotal disk. The pronotum is moderately rugose on the dorsal surface. The tegmina and wings surpass the apex of the abdomen. The lateral lobes of the pronotum are acutely produced, which character will distinguish it from both *Derotmema* and *Trimerotropis*.

Coloration. The color pattern is light, suffused with dark maculations. The posterior margins of the pronotum are outlined in light, without maculations, the sides of the pronotum marked with black in the male (absent in the female). The lower margins of the lateral lobes are light in both sexes. The tegmina have two dark bands extending from the edge, indistinct and broken into suffusions of maculations beyond the humeral angle, the area between the two bands without maculations, the distal two-fifths suffused with dark.

Only two specimens were collected at the Nevada Test Site, one male and one female. The hind wings in the male are red, in the female yellow (either color can appear in both sexes), with black fuscous band and several maculate areas in the clear wing tip.

The caudal femur has one black subapical band and a second incomplete band. The caudal tibiae are bluish gray mottled with brown.

Distribution. *Mestobregma impexum* is found from northern Arizona, southern Nevada and southern California, through Utah and into Idaho. The species was described from specimens taken at Milford, Beaver Co., Utah (type locality) and Cima and Bird Spring Mountains, California, from August 11 to September 5. "The species was scarce at Milford, occurring on sage covered ridges at 5000 feet and on relatively bare slopes, with scattered sage and yellow-flowered bushes, at 4900 to 5000 feet elevation." (Rehn 1919) At the Nevada Test Site it was found only in the sand dune area.

Habitats. This has been reported as "a rare species found in sandy or dry soil with scattered clumps of short grass in the sagebrush desert." (Ball, *et al.*, 1942). As indicated previously, both specimens were collected from the sand dune area. The collecting was made from an area of scattered shrubs (*Eriogonum* sp.) and small annuals and perennials with scattered grasses, rather than on the dunes themselves, although the areas are adjacent to each other. Extensive collecting was done during August and into November throughout this same area, but no other specimens were found.

The species was very active, flying some distance when disturbed. The red wings of the male made this a conspicuous insect in flight, but the yellow wings of the female could scarcely be discerned from the yellow-winged *Trimerotropis albescens*, so common in the area. The habits of the two were quite different, however, the *Trimerotropis* being a more sluggish insect, moving only short distances when disturbed.

Seasonal Occurrence. The two specimens were collected on July 30 and August 12.

Table 32. Size variation of *Mestobregma impexum*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, ECA, August 12, 1961	18.9	4.1	20.1	10.7	2.8
♀, ECA, July 30, 1961	23.4	4.7	23.4	12.5	3.3

Localities Represented. Specimens examined (adults): 2.

Study ECA, sand dune area, 2 adults, July 30 and August 12, no association was made with vegetation.

Genus *Trimerotropis* Stål

1873. *Trimerotropis* Stål Recensio Orthopterorum, 1, p. 118.

More species belong to the genus *Trimerotropis* than any other genus found at the Nevada Test Site. One of these (*T. pallidipennis pallidipennis*) is the most widespread acridid found. Members of the genus can be recognized by the following combination of characters:

Head of moderate size, the lateral foveolae distinct and triangular, the antennae filiform, of variable length. Disk of the pronotum nearly flat, smooth or granulate to minutely tuberculate on metazona, which is strongly broadened. Median carina of pronotum variable, cristate, even bilobate, or low on prozona, always less elevated on metazona, and with two transverse incisions. Metazona much longer than prozona, from one and one-half to more than twice as long. Lateral carinae indistinct or absent except occasionally on front of metazona and prozona. Posterior margin of pronotum distinctly angulate; lateral lobes of pronotum parallel, posterior angle well rounded. A tooth projected downward from the posterior angle of the lateral lobe is characteristic of two species. The tegmina and wings surpass the apex of the abdomen, occasionally are plain or commonly maculate over the entire surface of the tegmen, or much more frequently arranged in three well-marked bands, the two proximal bands generally much better defined than the distal band.

Key to the Species of *Trimerotropis*

1. Median carina of prozona cristate, the anterior and median lobes distinctly bilobate (Fig. 58); tegmina without solid, distinct fasciations or bands ..... *T. bilobata* Rehn and Hebard

   Median carina of prozona neither bilobate nor highly cristate, the lobes indistinct and more or less fused (Fig. 59) 2

2. Disk of wing yellow, always with a well defined black band 3

   Disk of wing blue or bluish, with or without a well defined black band 7

3. Caudal tibiae yellow or yellowish, occasionally light brownish in some dried specimens, but never blue, green or red[12] ..... *T. pallidipennis pallidipennis* (Burmeister)

   Caudal tibiae not yellowish 4

4. Caudal tibiae red; posterior angle of the lateral lobes of pronotum with a small tooth (Fig. 59) ..... *T. strenua* McNeill

   Caudal tibiae never red; posterior angle of lateral lobes of pronotum without a tooth 5

5. Caudal tibiae greenish (occasionally drying to tan) ..... *T. inconspicua* Bruner

   Caudal tibiae blue or bluish 6

6. Ground color white; tegmina white or very pale with three narrow dark bands; caudal tibiae light blue, sometimes drying to pale gray ..... *T. albescens* McNeill

   Ground color brown, never white; caudal tibiae dark blue, sometimes drying to almost black ..... *T. fontana* Thomas

7. Wing deep blue, with a well defined dark band ..... *T. cyancipennis* Bruner

   Wing light blue, without a dark band ..... *T. sparsa* Thomas

[12]An occasional dried specimen of *T. inconspicua* will show a yellowish tibia; but the color is actually greenish. They can be distinguished from *pallidipennis* by size, however. The *pallidipennis* males are larger than 20 mm, the females larger than 29 mm; *inconspicua* is always smaller than these measurements. In *inconspicua* the proximal fasciation of the tegmen is not conspicuous because of the dark coloration of the tegmen from this first fasciation to the base of the tegmen; in *pallidipennis* the first fasciation is distinct.

FIG. 58

FIG. 59

Figs. 58-59. 58, *Trimerotropis bilobata*, male, pronotum, lateral view. 59, *T. strenua*, male, pronotum, lateral view.

Trimerotropis bilobata Rehn & Hebard
(Figure 58; Table 33; Map 16)

1906. *Trimerotropis bilobata* Rehn & Hebard, Proc. Acad. Nat. Sci. Phila., LVIII, pp. 382-385.

Distinctive Features. The great elevation of the prozonal section of the median carina of the pronotum definitely characterizes this from any other species of the genus found at the Nevada Test Site.

Morphological Variation. This species supposedly has no distinct projecting process on the ventro-caudal angle of the pronotum, but the specimens from the Nevada Test Site are variable in this character. In a series of eight specimens collected at one time, two show a definite tooth, while the remainder show only a slight projection. Three specimens taken one week later are without any trace of a tooth.

Coloration. Body color light brown, with dark markings and lighter color on the head and pronotum. Tegmina with two complete transverse bars, the distal third with small irregular maculations chiefly along the veins. Wing disk yellow with a dark band. The caudal tibiae, in the specimens from the test site, are grayish-blue with a definite proximal ring, the colors fading in dried specimens.

Distribution. The type locality of the species is Antlers, Mesa Co., Colorado. Hebard (1929) commented: "We believe that it is very widely distributed over the Great Basin, in desert environment at lower elevations." This species has now been collected throughout the western states, the eastern limits being Arizona, Colorado, Wyoming and Idaho.

The species was common in Study 6A, the only locality at the Nevada Test Site where it was found. This study was located on the margin of Yucca Playa.

Habitats. In its original description, the authors commented on the habitat and habits of the species. "This species was found in the arid valley of the Grand river (the Colorado River) near Antlers station, where the only vegetation was a heavy growth of low cactus interspersed with occasional sage. Specimens were by no means uncommon and could have been easily taken in numbers had the cactus not interfered so much with collecting, as when alarmed the individuals would invariably seek refuge in the dense beds of cactus."

At the Nevada Test Site it was found only in the *Atriplex-Kochia* vegetation (*A. confertifolia* and *K. americana*), although its habits were not tied in with either shrub. It is a

Table 33 Size variation of *Trimerotropis bilobata*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6A, July 10, 1961	16.2	3.1	19.6	10.0	2.3
♂, 6A, July 10, 1961	18.0	3.2	18.2	9.0	2.2
♂, 6A, July 19, 1961	17.4	2.8	19.3	8.8	2.5
♂, 6A, July 19, 1961	17.4	3.0	19.8	9.4	2.4
♂, 6A, July 19, 1961	19.2	3.5	21.8	10.5	2.4
♀, 6A, July 12, 1961	22.0	3.9	23.7	11.6	2.8
♀, 6A, July 12, 1961	23.7	4.4	24.0	11.5	2.9
♀, 6A, July 12, 1961	23.4	4.3	24.0	11.9	2.95
♀, 6A, July 19, 1961	24.1	4.5	25.3	12.4	3.0
♀, 6A, July 19, 1961	26.8	5.6	28.6	13.2	3.6

moderate stridulator during flight and on occasion a good flier. It was much easier to capture than *Trimerotropis sparsa*, with which it was associated. It was always found on bare ground and would invariably fly to another bare area.

Seasonal Occurrence. The adults were collected from June 16 to August 16. They were most numerous during the month of July.

Localities Represented. Specimens examined (adults): 22. No nymphs were collected.

Study 6A, 22 adults, June 16 to August 16.

Additional Remarks. In describing this species, the authors remarked: "This species is one of a number which might with almost equal propriety be placed in either *Conozoa* or *Trimerotropis*, but which we have placed here chiefly because McNeill has considered its allied species as a member of *Trimerotropis* rather than *Conozoa*." In his catalogue to the world Orthoptera, Kirby placed it in *Conozoa*. The statement indicates that many of these related forms vary and might be confused with one another to some extent.

Over its complete range it is very variable in many external characters as well as the phallic complex of the male. The species should obviously be subdivided into geographic races.

Trimerotropis fontana Thomas
(Table 34; Map 16)

1876. *Trimerotropis fontana* Thomas, Proc. Davenport Acad. Nat. Sci., I, pp. 255-256.

Established Synonomy. *Trimerotropis juliana* Scudder; *Trimerotropis ferruginea* McNeill; *Trimerotropis calignosa* McNeill; *Trimerotropis caeruleipes* Scudder.

Distinctive Features. This species, as well as many of the members of the genus, is best characterized by color and pattern rather than morphology.

Coloration. The ground color of the species is ash-brown, the head and pronotum the darkest and without distinct markings. The tegmina show the typical trifasciation of the genus, the proximal fuscous band being the darkest and extending from the costal margin half way across the tegmen; the middle band, which is about in the middle of the tegmen, extends nearly or quite across the wing; the distal band is indistinct and situated about one-third the length from the apex of the wing; the apical portion of the tegmen is transparent, marked with a few pale fuscous spots. The wings are pale transparent yellow at the base, with a rather narrow, fuscous band and transparent apex with dark veins. The posterior femora are black (possibly bluish-black when living) internally at the base, with a black band toward the apex; the apex is black internally and fuscous externally. The antennae appear to be marked in some specimens with indistinct pale annulations. The caudal tibiae are deep blue in living specimens, changing to a dark color in dried specimens.

Distribution. The type locality of the species is Spring Lake, Utah Co., Utah. The present distribution includes all states of the Rocky Mountain area west to the Pacific Coast and north into British Columbia and Vancouver Island.

At the Nevada Test Site it was found only in one area (Kowich Valley Junction), near Rainier

Table 34. Size variation of *Trimerotropis fontana*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 12CF, August 12, 1961	17.4	3.8	18.8	11.0	2.9
♂, 12CF, August 12, 1961	17.5	3.9	19.6	10.8	2.7
♂, 12CF, August 21, 1961	17.9	3.3	18.8	10.0	2.7
♂, 12CF, August 12, 1961	18.5	3.9	19.9	10.4	2.8
♂, 12CF, August 12, 1961	18.6	3.7	20.2	10.5	2.9
♀, 12CF, August 21, 1961	21.8	4.7	24.2	11.3	3.1
♀, 12CF, August 12, 1961	23.8	4.7	24.2	12.4	3.4
♀, 12CF, August 12, 1961	26.5	5.8	26.2	12.7	3.5
♀, 12CF, August 12, 1961	27.2	5.1	28.5	14.0	3.8
♀, 12CF, August 12, 1961	27.7	5.0	25.9	12.7	3.7

Mesa, but it is probably present in most of the habitats suggestive of that study area.

Habitats. The grasshopper is a loud stridulator during flight, the typical flight of the individual being ten to fifteen feet. The species is very wary and flies often. Some specimens required nine or ten attempts before capture. One attempt to collect the species during cloudy, rain-threatening weather, indicated that the insect would try to escape by hiding in the shrubs or grass, rather than fly. The insects were found on very dark soil in an area of large clumps of *Elymus cinereus* and *Artemisia tridentata*.

Seasonal Occurrence. Collections in this area were made only on August 12 and August 21. Males and females were found on both dates. No nymphs were collected.

Localities Represented. Specimens examined (adults): 12.

Study 12CF, 12 adults, August 12 and 21.

Additional Remarks. The established synonomy indicates that variation is found within the group. The species is frequently referred to in the literature as *juliana*. Specimens collected near the type locality by the author show a tendency towards typical *cincta* in the black banding across the face. This character is shown in the minority of specimens in the series, however.

Trimerotropis albescens McNeill

(Table 35; Map 16)

1901. *Trimerotropis albescens* McNeill, Proc. U. S. Nat. Mus., XXIII, pp. 418-419.

Distinctive Features. This species is small in size for the genus, but the best distinguishing characters are found in the color and markings.

Coloration. The ground color is whitish, sparsely punctate with fuscous on the pronotum and conspicuously banded with fuscous on the tegmina and posterior femora. The tegmina are whitish like the body, with the basal band narrow and nearly solid, the median and third bands narrow and obviously made up of maculations, but very conspicuous; beyond the third fuscous band a few groups of fuscous annuli are present. All of the light areas are very broad and impunctate, except the basal, with a few dusky points, and an oblique fuscous dash just beyond the edge of the pronotum, best seen when the tegmina are at rest over the abdomen. The wing disk is light yellow, nearly transparent, bordered by a few fuscous clouds representing the fuscous band; the apex is hyaline. The posterior femur has the lower sulcus light except for a narrow stripe on the basal half and a band preceding the preapical light spot. The exterior face is whitish, except for a very distinct fuscous band preceding the preapical light band and a few faint clouds representing the other bands. The posterior tibia is blue with the base black, followed by a distinct light annulus.

Nymphs resemble adults in body color and are always found on the ground where they blend in with the environment.

The specimens at the Nevada Test Site are somewhat variable according to the color of sand upon which they are found. They are always very pale, however, and found on light sandy soils. Specimens found at lower elevations, where the sand is very white, show an exceedingly light color; those at higher elevations, where the sand is more yellowish, show a yellowish suffusion of the ground color.

The caudal tibiae are always light blue, frequently with blue under the femora, the ventral band may be solid, broken, or nearly in-

Table 35. Size variation of *Trimerotropis albescens*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, ECA, August 12, 1961	16.7	3.3	17.8	9.0	2.7
♂, ECB, August 11, 1961	17.0	3.7	18.6	9.2	2.6
♂, EM, July 23, 1961	18.0	3.4	18.9	9.2	2.7
♂, 3M, July 15, 1961	18.2	3.6	19.4	9.6	2.9
♂, ECB, August 11, 1961	20.8	4.1	21.4	10.3	3.2
♀, ECA, August 16, 1961	23.9	4.4	23.7	11.1	3.3
♀, 3CH, July 22, 1961	24.4	4.6	23.0	11.9	3.7
♀, ECA, July 30, 1961	24.8	4.8	24.2	12.6	3.7
♀, EM, July 23, 1961	25.8	4.9	24.2	12.5	3.6
♀, ECB, August 11, 1961	27.9	4.9	26.4	13.4	3.9

distinct. Specimens collected early in the season (these specimens were from lower elevations) averaged considerably paler than later specimens at higher elevations.

Distribution. The species is apparently limited in distribution to California and adjacent areas in Nevada. At the Nevada Test Site the species is found only in very light colored sand.

Habitats. LaRivers (1948) commented that the insect is an "effortless and wary flier." In collecting *albescens* from the test site it was determined that the insect is very active, though wary, with a distinct undulating flight and a loud stridulation during the flight. Generally, if the insect was not captured on the first attempt after the first flight, it would escape because of its remarkable resemblance to the environment and because of the scattered desert shrubs under which it would eventually hide.

As with other members of the genus, *albescens* is found on sand, never on vegetation until the extreme heat of the day forces them onto the branch tips of shrubs.

Seasonal Occurrence. Adults were collected from June 22 to October 14. Three subadults were found during the months of July and August. Adults were most common during July and August.

Localities Represented. Specimens examined (subadults and adults): 40.

Study ECA, sand dunes, 18 specimens, July 22 to October 14.

Study ECB, target rock area, 9 specimens, June 22 to August 11.

Area E, miscellaneous collecting near Area 12 garbage dump, 8 specimens, July 23 and 24.

Study 3CH, 1 specimen, June 27. More specimens were seen in this area, but were exceedingly difficult to collect.

Area 3, miscellaneous, near Study 3CH, 4 specimens, July 15.

Trimerotropis strenua McNeill

(Figures 56, 59; Table 36; Map 17)

1901. *Trimerotropis strenua* McNeill, Proc. U. S. Nat. Mus., XXIII, pp. 432-433.

Established Synonomy. *Trimerotropis montana* McNeill.

Distinctive Features. The prozonal carina of the pronotum is slightly elevated. The lateral lobe of the pronotum is armed with a distinct tooth (in the Nevada Test Site specimens) which character will distinguish it from the other members of the genus. The caudal tibiae are coral red.

Coloration. This species closely resembles *pallidipennis* in size, coloration and markings, but can be distinguished by the following markings: The tegmen has a very narrow basal band, distinct and well defined, the median and apical bands are less distinct, composed of dark maculations, the intervening light areas entirely unspotted. The wing disk is yellow, the fuscous band rather broad. The disk of the posterior femur has a black inner face, with two yellow bands on the apical half and one subapical black band. The lower sulcus is yellow. The outer face is plain, with a single fuscous transverse subapical band. The most distinct difference between *pallidipennis* and *strenua* is the color of the caudal tibiae. In *strenua* they are coral red; in *pallidipennis*, buffish-yellow.

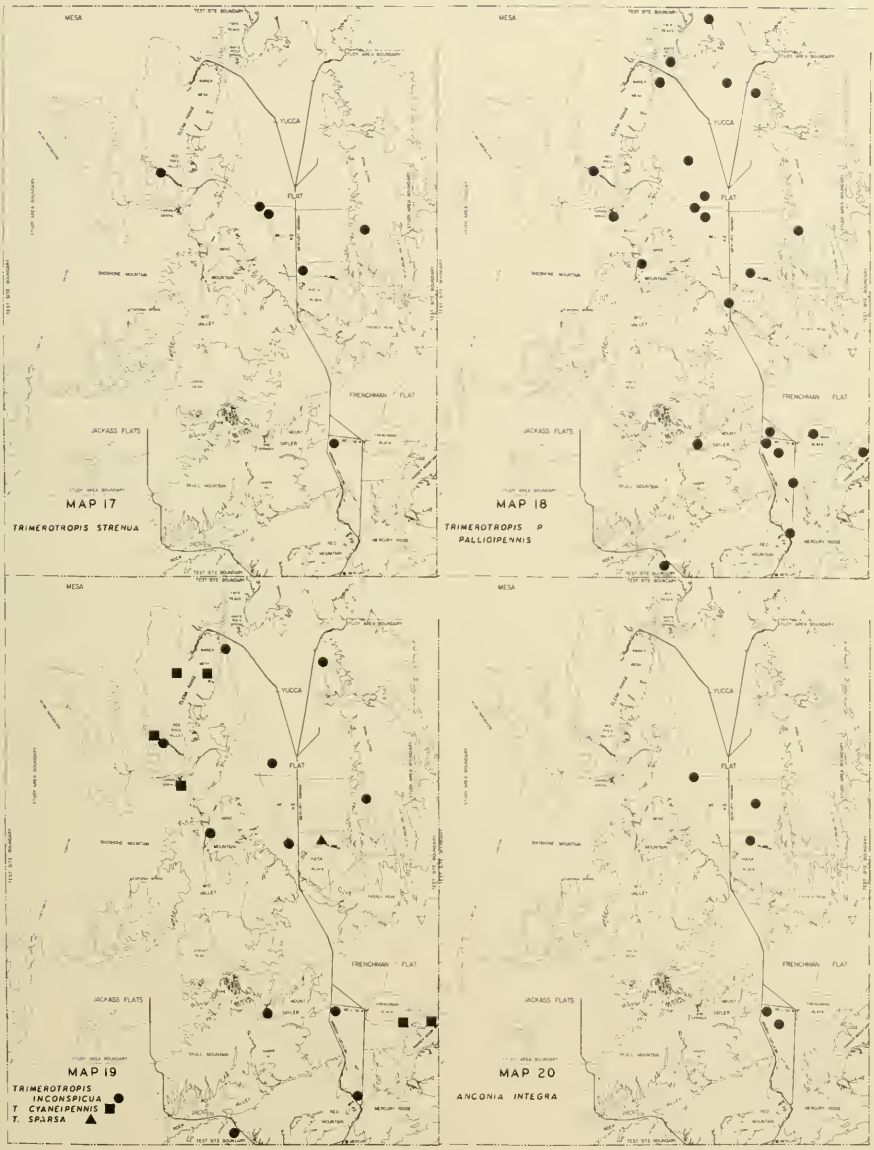
Distribution. The distribution of this species ranges from Oregon and Idaho south and east to western Colorado, New Mexico and western Texas and into northern Chihuahua, Mexico. The species has been described by Rehn and Hebard (1909) as a "Great Basin and interior desert form."

At the Nevada Test Site it was widely distributed, but limited seasonally.

Habitats. At the test site the species was found only in sandy areas where they were cap-

Table 36. Size variation of *Trimerotropis strenua*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, ECA, August 12, 1961	21.6	4.5	24.7	12.0	3.3
♂, ECA, August 18, 1961	23.9	4.2	25.7	11.6	3.1
♀, 1F, August 9, 1961	29.1	5.4	29.7	14.4	3.9
♀, ECA, August 12, 1961	29.1	5.5	30.6	14.5	3.8
♀, 1F, August 9, 1961	31.5	5.7	30.2	14.7	4.0


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 17
TRIMEROTROPIS STRENUA
MAP 18
TRIMEROTROPIS P
PALLIGIPENNIS
MAP 19
TRIMEROTROPIS
INCONSPICUA
T CYANEIPENNIS
T. SPARSA
MAP 20
ANCONIA INTEGRA

tured only with difficulty because of their contrasting markings and strong flight. The only feeding records are upon *Salsola kali*, upon which they were found in study 1F.

Seasonal Occurrence. Adults were collected from August 9 to September 4. All but two of the specimens were collected during the month of August. At the Nevada Test Site it apparently has a very short adult life. No nymphs were collected.

Localities Represented. Specimens examined (subadults and adults): 15.

Study 1B, 1 specimen, August 16.

Study 1F, 3 specimens, August 9 and 14, feeding on *Salsola kali*.

Study 3CD, 1 specimen, August 15.

Study 5A, 1 specimen, August 31.

Area 6, miscellaneous collecting, 2 specimens, August 15.

Study ECA, sand dunes, 7 specimens, August 12 to September 4.

Additional Remarks. The original description of *strenua* indicates its closeness to *T. californica* Bruner. They "may be but varieties of an exceedingly variable species." Rehn and Hebard also commented on the closeness of these species. In an examination of the phallic structures of the male the author found the two species practically inseparable, certainly no more than subspecies, but the original designation of species is maintained until complete revision is made of this very difficult genus.

Trimerotropis pallidipennis pallidipennis (Burmeister)

(Plate I, Figures 48, 55, Tables 37, 38, Map 18)

1838. *OEdipoda pallidipennis* Burmeister, Handb. Ent., II, p. 641.

Established Synonomy. *Trimerotropis vinculata* Scudder; *Trimerotropis similis* Scudder.

Distinctive Features. At the Nevada Test Site this insect is the most widely distributed and most common acridid appearing throughout the entire year. It can be recognized among the members of the genus *Trimerotropis* by its large size, sharing the large size in common with *T. strenua*, and by being the only member of the genus with yellow wings and yellow caudal tibiae.

Coloration. This is the large, flashy, yellow-winged species of the desert. Specimens from the Nevada Test Site have a definite tendency for "X" markings on the pronotum because of the contrasting colors. The insect has the usual dark band on the hind wings, typical of the entire group of band-winged grasshoppers. As stated previously, the caudal tibiae are yellow, often drying to a yellowish-tan.

The species has a very definite color as a response to soil, being light in light-colored soil, dark in dark-colored soil, more grayish in gray soil, and even (not observed at the Nevada Test Site) reddish in red soil.

Distribution. This grasshopper has, without a doubt, as great a distribution as any other grasshopper in the world. Rehn (1940) summarized its distribution as follows:

Table 37. Size variation of *Trimerotropis pallidipennis pallidipennis*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6A, July 12, 1961	22.0	4.3	24.7	11.1	3.0
♂, 5A, July 6, 1961	22.3	4.3	26.9	11.1	3.0
♂, 1G, August 9, 1961	22.8	4.6	25.5	10.9	3.3
♂, JA, October 15, 1961	23.2	5.0	27.2	12.5	3.5
♀, CM, July 6, 1961	29.2	5.8	32.8	14.6	4.3
♀, 5M, October 3, 1961	30.3	6.2	32.7	15.0	4.2
♀, 5E, July 18, 1961	30.5	5.7	31.5	15.1	4.1
♀, 5A, July 6, 1961	32.3	6.0	35.1	14.5	4.2
♀, CM, September 30, 1961	32.4	7.0	34.8	15.5	4.4
♀, 5A, July 11, 1961	33.2	6.1	32.7	15.2	4.1
♀, JA, August 3, 1961	34.0	6.2	35.7	15.5	4.5

"This wide-ranging and quite variable subspecies is one of that interesting group of forms which have marked discontinuous distribution. Almost universally distributed over the western United States west of the eastern edge of the Great Plains except in boreal areas, and occurring from depressions below sea-level to considerable elevations, where the form is often the sole geophilous acridid, it extends southward in arid or semi-arid Mexico at least as far as the state of Oaxaca . . . . From this point southward it is absent until sub-Andean conditions in southern Ecuador and Peru are reached . . . a third area, in which the race is apparently as abundant locally as in the western United States, extends from Bolivia at the Argentina border . . . southward . . . and eastward. . . ."

It is found distributed over the entire Nevada Test Site except at highest elevations such as Rainier Mesa and other similar areas, where it should be present, but was not collected.

Habitats. This acridid is at times a very loud stridulator during flight, is a very strong flier, and difficult to approach during optimum temperatures. The species is invariably found in a clearing, except during extreme temperatures of the summer when it may be found on vegetation, usually the highest tips of the shrubs. When disturbed it always lands in a clearing and when approached increases its flight distance with each stop as it is pursued.

In the course of chasing and capturing one female three attempts had been made and the next flight took her in the area of a male of the same species. The male was not observed until he gave a quick short jump. He was observed approaching the female from a distance of about six feet in a series of quick, short, jerky movements (about one body length at a time), often flexing his hind legs. In the meantime the female had flexed her hind legs in the same manner. At a distance of about twelve inches he stopped and the only movement of either was the characteristic waving of the antennae. He then quickly approached her and jumped on her back from the side in a position of copulation. After about two seconds he jumped off and almost immediately flew about 25 feet. An attempt was then made to capture the female, but she was very elusive and after six or eight attempts and covering at least 75 feet in a circle she again lit in the vicinity of the same male. He went through the same movements as before, except that he stayed on the back of the female for about ten seconds. Almost immediately, upon parting, I tried to collect both specimens, but the female flew away. Again I followed her and the course took her in proximity of a second male, who carried out the same manners as the first, but without actually mounting the female. As he hopped slowly away from the female I was able to capture them both.

In the late season and as the temperatures decrease with the approach of winter, the species is found less frequently, but even during warmer days of winter it can be found in the bright sunshine. The colder temperatures bring about a change in body color, and after the first cold night the specimens exhibit a darkened sternum and abdomen, very suggestive of *Dissosteira carolina*.

The species was commonly observed about the lights at night.

Seasonal Occurrence. Adults were first collected on March 11; the last collecting date was November 28. Nymphs were first collected on December 8 and present into July. No specimens, nymphs or adults, were collected during the months of January and February, probably because collecting activities had slowed down considerably, but the one nymph present in December, and again in March, would indicate that they would have been present on warm days during those months, seeking protection during the cold days, and that they overwinter in the nymphal stage. They were nearly equal in abundance during the months of June through October. In November their numbers sharply decreased. (See Table 3S for summary of specimens of *pallidipennis* throughout the test site.)

Localities Represented. Specimens examined (nymphs and adults): 299.

Salsola (studies 1F and 5P), 19 specimens, June 19 to November 3.

Grayia-Lycium (studies 1B, 1G and 4A), 78 specimens, April 5 to December 8 (last adult collected in November; December 8 record was one nymph).

Lycium (Study 5E), 18 specimens, March 18 to July 27.

Larrea-Franseria (studies 5A, 5CQ, 3CD), 27 specimens, April 8 to October 1.

Atriplex-Kochia (studies 6A and miscellaneous), 17 specimens, April 27 to August 14.

Coleogyne (studies 10D and Area 6 miscellaneous), 24 specimens, June 14 to August 28.

Artemisia (studies ECB, TA, TCB and miscellaneous), 14 specimens, June 22 to August 18.

Cane Springs (CBA and CM), 24 specimens, May 27 to October 14.

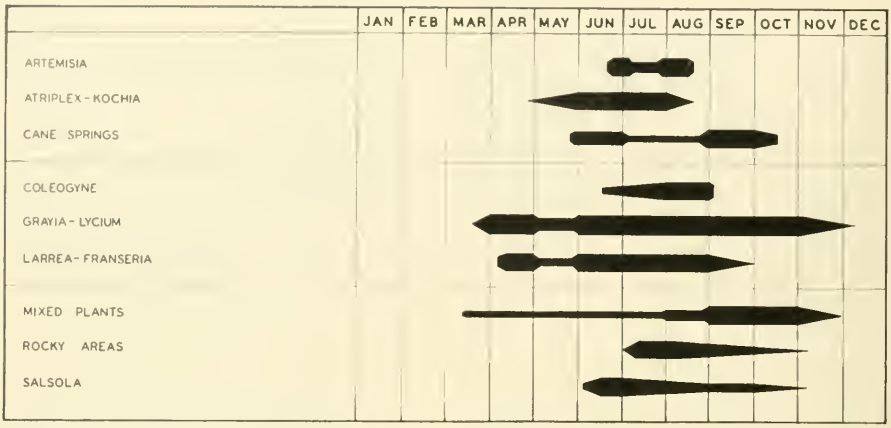


Table 38. Seasonal distribution of *Trimerotropis pallidipennis pallidipennis.*

Mixed vegetation (studies JA and ECA), 49 specimens, March 19 to October 15.

Study 5CK, rocky area, 8 specimens, July 14 to November 6.

Area 5, miscellaneous collecting, 18 specimens, March 11 to October 16.

Area 15, miscellaneous collecting, 1 specimen, November 28.

Study ACC, 9 specimens, October 2.

Trimerotropis inconspicua Bruner

(Table 39; Map 19)

1904. *Trimerotropis inconspicua* Bruner, Bull. Agr. Exp. Sta. Colorado, 94, p. 59.

Established Synonomy. *Trimerotropis viriditibialis* Henderson.

Distinctive Features. This species is very similar to *T. pallidipennis pallidipennis,* but smaller, and can be recognized by the characters given in the key and by the remarks under "Coloration."

Coloration. This species is lighter in color than *pallidipennis,* which it resembles, except for the tegminal area between the proximal band and the base of the tegmen, which area is as dark, usually, as the band; tegminal bars are comparatively narrow, but well defined, converging posteriorly. While the bands on the tegmina are not solid they are quite prominent and made up of clusters of dark dots or by the infuscation of certain veinlets. On the basal portion these bands are narrower than usual and show a decided tendency towards converging

Table 39. Size variation of *Trimerotropis inconspicua.*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 3CD, August 15, 1961	17.0	3.4	18.3	9.5	2.8
♂, CBA, July 18, 1961	18.2	3.3	19.5	9.6	2.5
♂, JA, July 18, 1961	18.4	3.6	19.0	9.3	2.4
♂, JA, October 4, 1961	18.5	3.7	19.3	9.6	2.7
♂, 3CD, August 15, 1961	19.2	3.8	22.3	10.0	2.9
♀, 1G, July 10, 1961	22.7	4.8	23.9	11.2	3.5
♀, 5M, September 26, 1961	23.3	4.6	24.9	11.5	3.3
♀, 3CF, June 27, 1961	23.6	4.9	25.1	11.8	3.4
♀, JA, October 15, 1961	24.6	5.0	25.4	12.3	3.2
♀, TA, July 17, 1961	28.5	6.0	26.9	12.9	4.0

posteriorly, while the apical portion is nearly destitute of markings except for the infuscation here and there of a few veinlets. The wing has a very pale greenish-yellow disk, crossed about the middle by a narrow fuliginous band, with a transparent apical portion beyond the dark band. The lower sulcus of the caudal femur is yellow or at least with two pale bands. The hind tibiae are pale greenish or slightly yellowish, except on the extreme base where they are dark brown and they are somewhat infuscated beyond the subbasal pale annulus and apically. The front and middle legs and antennae are well marked with dusky annulations.

Distribution. The type locality of this species is Palisade, Mesa Co., Colorado. At the time of description it had very limited known distribution. The species has been collected in Arizona, and Henderson's description of *viriditibialis* was from Central Utah. At the Nevada Test Site it is widely distributed, though not abundant, in many of the areas.

Habitats. The species is not an active flier, moving only five or six feet (males) or not attempting to move before capture (females). No attempt was made to correlate it with any vegetation types because *Trimerotropis*, generally, is found on bare ground and upon alighting returns to bare ground.

Seasonal Occurrence. The species was collected from June 12 to October 15. Adults were equally common through the months of June to September. One nymph was assigned to the species, and only one subadult was found. It is likely that the nymphs of *inconspicua* could be confused with those of *pallidipennis*, and may be told only by the general pronotal characters, the smaller size, and the banding on the femora.

Localities Represented. Specimens examined (nymphs and adults): 49.

Study 1G, 2 specimens, July 10.

Study 3CD, 2 specimens, August 15.

Study 3CF, 1 specimen, June 27.

Study 5A, 1 specimen, July 18.

Area 5, miscellaneous collection, 4 specimens, September 26.

Area 6, miscellaneous collections, 1 specimen, August 11.

Study 10D, 4 specimens, June 14 to August 16.

Study CM, Cane Springs, 1 specimen, August 19.

Area E, miscellaneous collecting near Area 12 garbage dump, 1 specimen, July 24.

Studies JA and CBA, 23 specimens, June 12 to October 15. (These two studies are grouped because of a mixed vegetation.)

Study TA, Midvalley, 9 specimens, June 22 to August 17.

Additional Remarks. This species shows considerable variation in both morphology and color pattern throughout its distribution at the Nevada Test Site. Specimens were sent to the U. S. National Museum for confirmation.

Trimerotropis cyaneipennis Bruner

(Table 40; Map 19)

1889. *Trimerotropis cyaneipennisn* [Sic.] Bruner, Proc. U. S. Nat. Mus., XII, pp. 68-69.

Established Synonomy. *Trimerotropis cyanea* Scudder.

Distinctive Features. Coloration is the main distinguishing character of the species. The only other dark blue winged species, *Leprus glaucipennis* Scudder, is so distinct from the genus *Trimerotropis* morphologically that it should not be confused with the present species.

Table 40. Size variation of *Trimerotropis cyaneipennis*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂♀, 5HQ, August 12, 1961	15.7	3.5	19.0	9.1	2.2
♂, 12E, July 24, 1961	20.6	3.7	22.3	9.9	2.7
♂, 12E, August 12, 1961	21.3	3.8	21.8	10.8	2.8
♂, 12E, August 12, 1961	21.6	4.4	23.7	12.8	3.0
♀, 12A, June 26, 1961	27.0	5.3	28.7	13.2	3.5
♀, 12A, July 27, 1961	27.1	5.3	29.3	13.6	3.5
♀, 12A, July 9, 1961	28.3	5.4	28.9	13.1	3.3
♀, 12A, August 11, 1961	29.9	5.8	30.0	14.1	3.9

Coloration. The general body color is dark gray, often with a ferruginous tinge, profusely mottled and marked with fuscous. The head is mottled with gray and brown. The pronotum is marked with the same contrasting colors, the tegmina are mottled with rather large quadrate brownish spots, which in most specimens are grouped into three bands or patches, the first occupying the basal third, the second the center of the middle, and the third the outer third of the tegmen, not forming definite bands as in most of the other members of the genus.

Wings very dark blue on their basal half, crossed beyond by a rather wide fuliginous band that does not continue around towards the anal angle; the apical third hyaline with the veins black. The caudal femora are crossed externally by three moderately broad oblique brown bands, internally with the basal half and a single black band in advance of the light yellow preapical annulation. Caudal tibiae deep coerulean blue with a light basal annulation, the spines black-tipped. Abdomen deep blue above in some specimens, inclining to greenish along the sides, suffused with gray below.

Distribution. This species was described from specimens collected in the Salt Lake Valley, Utah, near the mouth of Ogden Canyon. It ranges from western Texas west to California and north to southern Idaho. At the Nevada Test Site it was quite common on Rainier Mesa, less common in the other areas where it was found.

Habitats. The species is a strong flier and loud stridulator. One specimen was observed flying for more than 100 feet before alighting. The flash of blue as the insect flies is very obvious.

The specimens from Study 5HQ average smaller and are considerably lighter in color, suggesting a response to soil environment, inasmuch as Area 12 has very dark soil; Area 5, much lighter soil.

There is no correlation between vegetation and the species.

Seasonal Occurrence. Adults were collected from June 26 to October 4. Most of the specimens were collected during the month of July. No specimens were collected during the month of September, as no collecting trips were made onto Rainier Mesa, and only one specimen was captured in October. No nymphs were collected.

Localities Represented. Specimens examined (adults): 76.

Study 5HQ, 4 specimens, August 12 and 13. The occurrence of this species at this low elevation is surprising. It was an area of *Salsola kali.*

Studies 12A and 12E, Rainier Mesa, 58 specimens, June 26 to August 21. At least 90 percent of the specimens were collected in Study 12A, the disturbed area.

Study ACC, 1 specimen, October 4.

Area E, miscellaneous collecting near the Area 12 garbage dump, 10 specimens, July 23 and 24.

Study TCB, 3 specimens, August 12 and 13.

Trimerotropis sparsa Thomas
(Table 41; Map 19)

1875. *OEdipoda sparsa* Thomas, Wheeler's Report, Geog. Geol. Expl. Surv. West 100th Meridian, pp. 883-884.

Established Synonomy. *Trimerotropis azurescens* Bruner; *Trimerotropis perplexa* Bruner.

Distinctive Features. The species is distinct as being the only member of the genus without a black band. In flight it may not be recognized because of the transparent light blue wings.

Coloration. The body of the insect is dull grayish brown throughout, sprinkled with fuscous dots. The tegmina are somewhat darker on

Table 41. Size variation of *Trimerotropis sparsa.*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6A, July 26, 1961	19.6	3.9	20.0	9.5	2.6
♂, 6A, July 26, 1961	20.5	4.3	21.9	10.4	2.8
♂, 6A, July 17, 1961	21.2	4.3	21.3	10.9	2.8
♂, 6A, July 17, 1961	21.3	4.5	21.6	10.8	2.7
♀, 6A, August 16, 1961	27.3	5.5	26.8	12.6	3.3

the basal third, the other two thirds being lighter and sparsely sprinkled with the fuscous dots. The wings are a transparent light blue with prominent and strong veins. The caudal tibiae are yellow.

Throughout its range, especially to the northeast there is considerable variation in color and intensity of the wings, and the development of the wing band. The specimens from the Nevada Test Site, however, are quite consistent in pattern and coloration.

Distribution. The species is widely distributed in all of the western states from North Dakota, Montana, and Alberta, Canada, south to western Texas and New Mexico (the type locality) and west into the Great Basin. At the Nevada Test Site it was found in only one study, in the *Atriplex-Kochia* association immediately adjacent to Yucca Playa.

Habitats. A very loud stridulator and strong flier, this species flies short distances of 20 to 25 feet, loudly stridulating with each flight. It is a very wary insect on the ground and, at times, it has been impossible to approach any nearer than ten feet. At least a dozen attempts were made on one specimen, which finally escaped by a longer flight and apparently hid in an *Atriplex*.

Seasonal Occurrence. Adults were collected from June 28 to August 16. They were most numerous in July. No nymphs were collected.

Localities Represented. Specimens examined (adults): 10.

Study 6A, 10 specimens, June 28 to August 16.

Genus *Anconia* Scudder

1876. *Anconia* Scudder, Appendix H9 of Appendix JJ of Ann. Rep. Chief Eng. U. S. Geogr. Surv. W. 100th Meridian, pp. 514-515.

Anconia integra Scudder

(Figure 45; Table 42; Map 20)

1876. *Anconia integra* Scudder, Appendix H9 of Appendix JJ of Ann. Rep. Chief Eng. U. S. Geogr. Surv. W. 100th Meridian, p. 515.

Distinctive Features. There is a remarkable size difference in the sexes of this species. The females are large, the males small. Morphologically they are distinct from other species found at the Nevada Test Site. The head and most of the anterior lobe of the pronotum are smooth, the posterior lobe of the pronotum profusely punctulate. The head and pronotum are both small in comparison to the expanded mesosternum and metasternum. The tegmina and wings are very long, the caudal femora very long and narrow. The pronotum is broadly rounded posteriorly.

Coloration. This species is variable in color from ash gray to yellow with minute fuscous maculations on the pronotum and head, and with larger maculations on the tegmina. The lateral carinae of the pronotum are noticeably marked with a cream-color to produce an "X" on the pronotum. Occasionally, especially the females, the entire body, including the tegmina and caudal femora, is green with yellow markings and brown maculations. The wings are transparent, clear, or slightly smoked in some specimens, with the larger veins fuscous. The caudal femora have two indistinct black bands both externally and internally, the outer central area of the caudal femora with ash-gray wash. The caudal tibiae are the same color as the body, bifasciate proximally.

Most of the body markings fade somewhat in drying.

At the Nevada Test Site the brown specimens predominate, the green phase was only occasionally found, and specimens exhibiting the true yellowish phase were not collected.

Table 42. Size variation of *Anconia integra*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 6A, July 10, 1961	21.0	4.1	21.8	11.4	2.3
♂, 5E, August 13, 1961	21.9	4.6	25.1	10.9	2.3
♂, 5E, May 27, 1961	22.0	4.7	23.9	12.6	2.4
♀, 5E, April 29, 1961	34.5	7.0	32.7	17.1	3.3
♀, 5E, September 9, 1961	36.7	7.9	34.3	17.7	3.7
♀, 3CI, June 29, 1961	38.0	7.6	37.6	18.7	3.6

Distribution. The range of the species is now known to extend from Las Vegas, Nevada, and Death Valley, California, south to Indio, California and Yuma, Arizona, and from the western portion of the Mohave Desert to at least the vicinity of Tucson, Arizona. The Nevada Test Site distribution is limited to lower elevations.

Habitats. The collecting results at the Nevada Test Site somewhat contradict some of the published comments on this species. Caudell (1908) reported that "these grasshoppers are wild and hard to catch, especially as they often fly in thorny shrubs, where they are very difficult to get. They are protectively colored when on the ground and when flushed fly long distances, especially the females which fly much farther than the males." Rehn and Hebard (1908) reported: "At Tucson this species was taken among high weeds both in damp and dry locations. They were very wary and alert and when missed flew for some considerable distance. A preference to alighting on the ground when pursued rather than on weeds and bushes was observed, though invariably first discovered among vegetation."

At the Nevada Test Site this grasshopper was found only on alkaline outwashes. Several specimens were found directly on *Atriplex confertifolia*. More often, especially the males, they were found on the ground, where they were well concealed. It was observed that these specimens were weak fliers, never flying high nor far. Many of the specimens were collected during the middle of the day when they should be most active.

No nymphs were collected, but the species did show a preference to *A. confertifolia*, in which they were well concealed, and upon which they fed.

Seasonal Occurrence. Adults were collected from March 14 to September 9. They were most numerous during April, May and June, and are a late spring and very early summer form.

Localities Represented. Specimens examined (adults): 37.

Study 1B, 1 adult, August 27, vegetation not recorded.

Study 3C1, 1 adult, June 29, vegetation not recorded, probably on *A. confertifolia*.

Study 5A, 1 adult, August 31, vegetation not recorded, although the area is predominantly *Larrea divaricata* and *Franseria dumosa*.

Study 5E, 28 adults, March 14 to September 9, always on *A. confertifolia* or on alkaline ground.

Study 6A, 6 adults, June 14 to July 10, on *Atriplex confertifolia*. One specimen was found on *Kochia americana*.

Genus *Cibolacris* Hebard

1937. *Cibolacris* Hebard, Trans. Amer. Entom. Soc., LXIII, pp. 368-369.

Cibolacris parviceps aridus (Bruner)

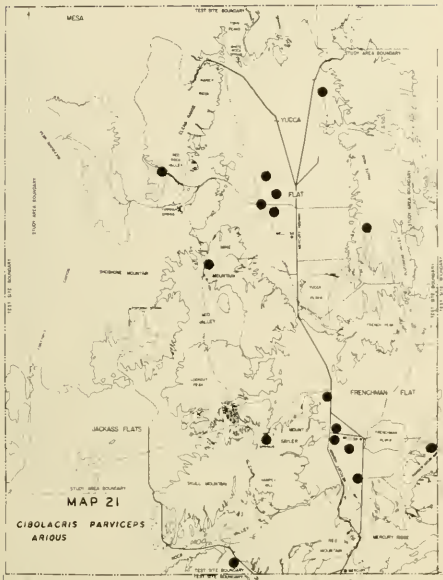
(Figure 44; Table 43; Map 21)

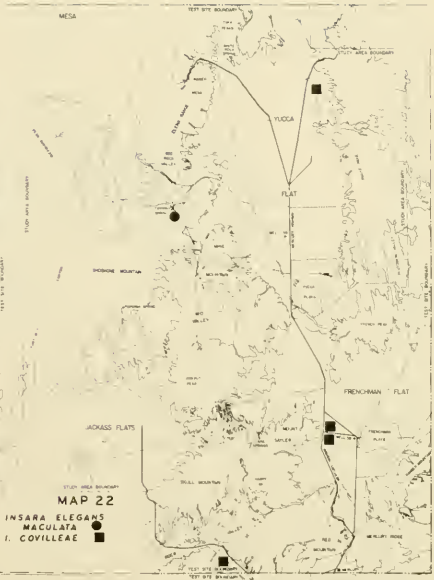
1889. *Thrincus* (?) *avidus* (= *aridus*) Bruner, Proc. U. S. Nat. Mus., XII, p. 78, pl. 1, figs. 2 and 3.

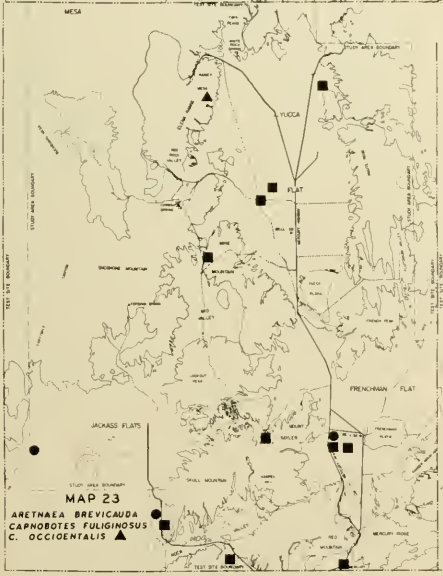
Distinctive Features. Form moderately robust, the general contour of the head suggesting *Anconia*, the vertex with fine lateral carinae suddenly and strongly convergent distad and briefly separated at the apex of the fastigium. The antennae are very short, the eyes more prominent. The pronotum is weakly sellate, definitely constricted in the cephalic portion (but not as decidedly so as in *Anconia*), the cephalic margin of the disk with two, usually definite, small adjacent median convexities. The disk of the pronotum is broadly rounded posteriorly. The caudal femora are short and robust. There is no trace of the band on the hind wing.

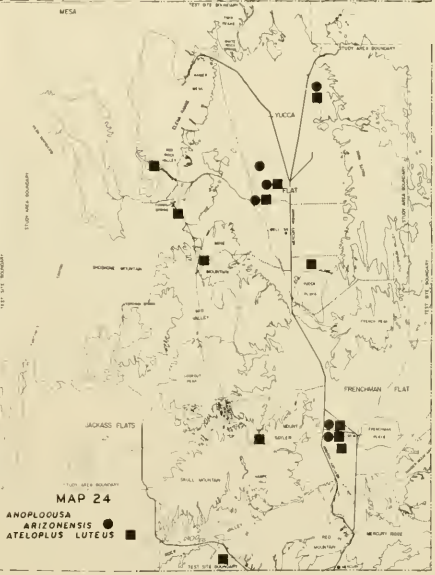
Table 43. Size variation of *Cibolacris parviceps aridus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur
♂, 5CQ, July 10, 1961	16.4	3.2	15.5	8.7	2.5
♂, CM, July 6, 1961	17.3	3.0	17.4	9.1	2.8
♂, JA, July 6, 1961	18.1	3.2	17.1	9.8	2.8
♀, 5B, July 3, 1961	27.8	4.2	24.0	13.9	3.6
♀, 5B, July 3, 1961	28.2	4.9	23.7	13.5	3.8
♀, 5E, July 13, 1961	31.6	5.7	26.4	13.6	3.8


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 21
CIBOLACRIS PARVICEPS
ARIOUS


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 22
INSARA ELEGANS
MACULATA
I. COVILLEAE


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 23
ARETHAEA BREVICAUDA
CAPNOBOTES FULIGINOSUS
C. OCCIDENTALIS


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 24
ANOPLOCOUSA
ARIZONENSIS
ATELOPLUS LUTEUS

Coloration. The color variation in this subspecies is interesting. The general ground color varies from very dark gray, brown, and even red-brown, to very light gray, buff, and almost white. There are usually rather coarse and scattered dark dots in varying degrees of contrast, some specimens presenting a decided speckled appearance. The insect has a strong tendency to duplicate the soil coloration. This is more noticeable over its entire range. From the White Sands area of New Mexico it is almost white; from southern Arizona, quite yellow; and from the red sands of southern Utah it takes on a red appearance. From the Nevada Test Site it has a tendency to intermediate colors, the yellows, grays, and light brownish-reds. The mauve-colored maculations blend in rather well with the mauve-colored rocks of the desert pavement upon which it may be found. The specimens show a definite tendency to the light "X" markings of the pronotum, so common with many of the desert acridids. This marking definitely blends in with the background.

The wings are pale bluish-green; the caudal tibiae delicate blue with a white basal annulus.

Nymphs may be recognized by the contrasting colors and the definite tendency of the "X" on the pronotum.

Distribution. This species is a true faunal indicator of the Lower Sonoran life zone, its distribution extending through the southwestern deserts from southwestern Texas and northern Chihuahua, Mexico, to southern California and north to southern Nevada and Utah.

At the Nevada Test Site it is as widely distributed as *Trimerotropis pallidipennis pallidipennis*, but has not been collected throughout the year as has that species. This may be a case of concealment in the habitat (*pallidipennis* being a showy insect) rather than not actually being absent from the environment.

Habitats. This species is exceedingly difficult to collect, though often numerous in the environment. Their ability to blend in with their environment is most remarkable of any other geophilous acridid at the test site.

They are always found on desert pavement, except during extremely high temperatures when they can be found resting on the vegetation off the ground. They are rarely seen until they move. When pursued they always alight in the open, flying only a short distance, but always are well concealed upon alighting. They apparently have the ability to detect the spot in the area where they will be remarkably well camouflaged. These statements can be made after watching and pursuing actually hundreds of specimens, male, female and nymphs, in all stages of development.

Hebard (1937) commented on the habitat of this group: "From the series before me it is evident that this insect prefers pebbly or coarse gravelly areas in washes particularly near or at the bases of the desert hills and mountains of the southwestern United States, but is able to reach considerable elevations (as high as 6950 feet) in such environment. It is very often encountered, but is seldom numerous and almost disappears in the dry and hot valleys. Adults are present almost throughout the year as well as small immatures. I am inclined to believe, however, that the largest number of adults are present from May to early July over most of its range."

Contrary to what Hebard remarked about this insect not being found commonly in the valleys, at the Nevada Test Site it is most common in those areas of low shrubs immediately surrounding the playa lakes, wherever small pebbles are scattered on the ground. It is never found in the alkali outwashes, but is always associated with the desert pavement. It is also found at higher elevations (but not on Rainier Mesa nor at the highest elevations on the test site) on rocky terrain.

It is definitely attracted to lights at night.

Seasonal Occurrence. Nymphs were collected from March 11 to the middle of June. Adults were found from April 1 to October 14. The group is most numerous from April through July. (See Table 44 for comparative distribution.)

Localities Represented. Specimens examined (nymphs and adults): 287.

Salsola studies (1F), 13 specimens June 19 to August 16.

Grayia-Lycium studies (1B, 1G, 4A, 5E), 101 specimens, April 8 to August 16.

Larrea-Franseria studies (3CD, 5A, 5B, 5CQ, 5M), 149 specimens, March 11 to October 2.

Atriplex-Kochia studies, no specimens collected. This is one of the two major associations where the species was not found.

Coleogyne studies (10D), 5 specimens, June 16 to August 14.

Artemisia studies (TA), 1 specimen, June 16.

Pinyon-Juniper studies, no specimens collected. The group was not found at this high elevation on the test site.

Mixed vegetation studies (ECA and JA), 12 specimens, April 28 to October 14.

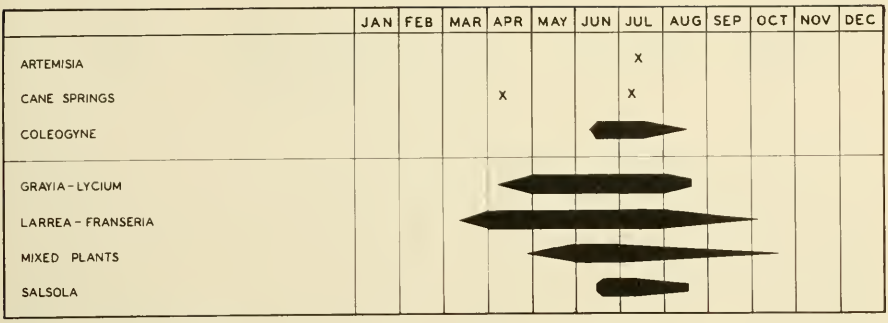


Table 44. Seasonal distribution of *Cibolacris parviceps aridus*.

Study 3CF, *Tetradymia-Yucca* association, 4 specimens, June 27.

Study CM, Cane Springs, 2 specimens, April 8 and July 6.

Study ACC, 1 specimen, October 2.

Superfamily Tridactyloidea
Family Tridactylidae
(Figures 8, 9)

The pygmy mole crickets, or sand crickets, are small burrowing orthopterans found along sandy margins of streams or other bodies of water. They can be distinguished from other orthopterans by the characters given in the key. Until recent times they were considered to be closely related to the true crickets, but internal morphology placed them in their true position, more nearly related to the acridids. They are definitely adapted for fossorial habitat.

These minute orthopterans are very agile creatures and very powerful jumpers. They are exceedingly difficult to collect because they are difficult to spot. If known to be present in the area, they can best be captured by sweeping along the edges of the water and by sweeping the vegetation along the margins.

Representatives of this group have not been collected from the Nevada Test Site, but they are widely distributed over the United States, and two species approach the area in their known distribution. They could only be found around margins of perennial water sources, especially in sandy areas, and the Nevada Test Site may not actually have an environment conducive to their survival.

Only two species are found in continental United States. *Tridactylus apicalis* Say, the larger of the two has one-segmented caudal tarsi; *T. minutus* Scudder has the hind tibia equipped with a pair of short plates used in swimming, but the hind tarsi are absent.

Suborder Ensifera
Superfamily Tettigonioidea

To the suborder Ensifera belong the major sound-producing orthopterans, the so-called long-horned grasshoppers, the camel or cave crickets, and the true crickets. It consists of an assemblage of many different superficial types of insects, all related in that their antennae are very long, usually, sometimes several times the length of the body, very gradually tapering and with many segments. The tegmina, when present, are generally somewhat membranous,

Key to the Families of Ensifera

1. Tarsi 4-segmented (Fig. 60); tegmina and wings, when developed, sloping at sides of body, may be reduced to small lobes, barely projecting beyond the pronotum, or apparently non-existent 2

   Tarsi 3-segmented, the middle segment minute (Fig. 61); tegmina and wings, when present, horizontal in greater part (Fig. 62) ..... Family Gryllidae, page 112

2. Wings generally present; front tibiae with an auditory organ (Fig. 63) ..... Family Tettigoniidae, page 82

   Wings absent; no auditory organ on front tibiae ..... Family Gryllacrididae, page 91

FIG. 60

FIG. 61

FIG. 62

FIG. 63

Figs. 60-63. 60, *Anoplodusa arizonensis*, female, caudal tarsus, lateral view. 61, *Acheta assimilis*, female, caudal tarsus, lateral view. 62, *A. assimilis*, female, head, pronotum, tegmina, dorso-lateral view. 63, *A. arizonensis*, male, cephalic tibia showing auditory apparatus, lateral view.

but in some groups are dense and opaque. Stridulation is accomplished by the sound-producers by the modified anal or dorsal field of the tegmina. One tegmen is rubbed over the other. Auditory organs, if present, are on the cephalic tibiae.

The female ovipositor is usually long and well developed, sometimes spear-like or sword-shaped, often sharply upturned and greatly curved, and composed of four or six valves.

Family TETTIGONIIDAE

Many different and distinct forms can be found among the long-horned grasshoppers. They can be distinguished, however, by the characters given in the key: the extremely long, finely tapering antennae, the four-segmented tarsi, without arolia between the claws, a compressed, blade-like ovipositor in the female, organs of hearing situated on the front tibiae, and tegmina, if fully developed, with the larger part of their surfaces sloping at the sides of the body. The tegmina of the males are modified to form a sounding-board for the stridulating apparatus. This is located near the base of the tegmina and consists of a transverse ridge bearing a series of teeth which act upon a stiffened edge on the outer tegmen, causing both to vibrate and produce a scraping sound.

Winter is usually passed in the egg stage and hatching takes place in the spring. Growth is rapid and maturity reached in midsummer. The oviposition of the females in early autumn ends the cycle.

These insects are most attractive in appearance and many of them have a distinctive song. Most species can be identified by their songs and may often be caught by following the sound at night. They are commonly nocturnal insects.

Key to Subfamilies of TETTIGONIIDAE

First two tarsal segments lacking a lateral groove; posterior margin of hind tibiae with its two series of spines continued to tibial apex. Long, slender-winged species ..... Subfamily Phaneropterinae, page 82

First two tarsal segments with lateral groove (figs, 60, 64); spine series not continued to tibial apex; wings long or greatly reduced. If wings long, the insects are large and heavy-bodied. .....Subfamily Tettigoniinae (=Decticinae), page 86

FIG. 64

Fig. 64. *Capnobotes fuliginosus*, female, caudal tarsus, lateral view.

Subfamily PHANEROPTERINAE

Key to the Genera of PHANEROPTERINAE

Comparatively robust species; tegmina broad, barred with white or maculate; hind wings not over 7 mm. longer than tegmina (Fig. 65). Usually found in trees and on higher shrubs ..... *Insara* Walker

Extremely slender, long-legged species; tegmina, if present, uniformly colored, hind wings more than 7 mm. longer than tegmina (Fig. 66); male with first abdominal tergite specialized as in Figure 67. Usually found in grass and on low plants ..... *Arethaea* Stål

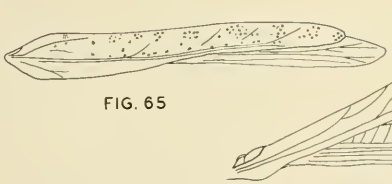


FIG. 65

FIG. 67

FIG. 66

Figs. 65-67. 65, *Insara elegans maculata*, female allotype, tegmen and wing. 66, *Arethaea brevicauda*, male, tegmen and wing. 67, *A. brevicauda*, male, modification of first abdominal tergite, cephalo-lateral view.

Genus *Insara* Walker

1869. *Insara* Walker, Cat. Derm. Salt. British Museum, II, p. 267.

Key to the Species of *Insara*

Dorsum of pronotum deplanate (Fig. 68); tegmina marked with a slight herringbone pattern of light green, conspicuously maculate with dark dots. (Fig. 65) ..... *I. elegans maculata* Barnum, new subspecies

Dorsum of pronotum extremely sellate (figs. 69, 70); tegmina conspicuously marked with a series of large white or pale greenish spots ..... *I. covilleae* Rehn and Hebard

FIG. 68

FIG. 69

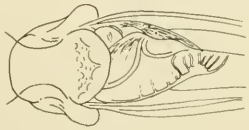


FIG. 70

Figs. 68-70. 68, *Insara elegans maculata*, female allotype, pronotum, dorso-lateral view. 69, *I. covilleae*, male, pronotum, lateral view. 70, *I covilleae*, male, pronotum and proximal tegmina showing stridulating mechanism, dorsal view.

Insara elegans maculata Barnum, new subspecies[13]

(Figures 65, 68, 71-73; Map 22)

Holotype Male, NEVADA, Nye Co., Nevada Test Site, one-half mile south of Tippipah Springs (Study TCB), July 16, 1961 (A. H. Barnum, collector).

Allotype Female. Same locality as Holotype male, October 14, 1961 (A. H. Barnum, collector).

Both Holotype and Allotype are deposited in the U. S. National Museum.

Comparative Features. This insect shows few structural differences when compared to *I. elegans elegans*. It is somewhat smaller. The distal portion of the tegmina and wings are narrow, the marginal field of the tegmina narrowing abruptly distad from the proximal third as in *elegans*. The ovipositor is bent more decidedly upward than in *elegans*. Compared to *I. elegans consuetipes* the tegmina are very maculate.

Description. General body markings as in *elegans*, the head greenish, more pronounced than the rest of the body except the tegmina. Tegmina with a distinct herringbone pattern of light and dark green, about as in *elegans*, but conspicuously punctate with dark purplish dots, these dark areas often completely filling cells, generally less extensive. Pronotum and stridulating mechanism of male as shown in Figure 72. Ovipositor of female (Fig. 71) with distal half of ventral valve brilliant green, basal half and dorsal valves dull yellowish green, all valves terminated by dark tips. The male cercus and terminal abdominal appendages as shown in Figure 73. Tibiae, distal palpi and basal antennae brilliant green, the distal half of antennae an-

[13]Named after the maculate appearance of the tegmina.

nulate with dark. Caudal femora marked with dark spots on both ventral margins. Veins on anal field of female tegmen marked with purplish brown as in *I. tesselata*. Abdomen of nymphs punctate with purple dots.

Size Variation.

(Measurements in millimeters)

	Holotype Male	Allotype Female
Length of body	14.1	17.8
Length of pronotum	3.0	3.0
Greatest width of dorsal pronotum	2.1	2.1
Depth of pronotum	2.6	2.6
Length of tegmen	21.8	24.1
Length of caudal femur	16.0	15.8
Breadth of caudal femur	1.7	1.8
Wings projecting beyond tegmina	3.1	3.0
Length of male cercus	1.1	
Length of female ovipositor		5.0

Distribution. This subspecies was found only in the type locality at the Nevada Test Site. The area consisted of a small wash near Tippipah Springs. The vegetation where the unimproved road crosses the wash consisted of a rather dense stand of *Purshia glandulosa*, *Chrysothamnus viscidiflorus*, *Artemisia tridentata*, other shrubs, and numerous smaller perennials and annuals. Nearby is a thicket of oak, *Quercus gambelii*.

Habitats. This insect was first discovered as nymphs from sweeping bitterbrush, *P. glandulosa*. On July 16, 1961, the one male holotype was collected, and on October 14, 1961, the one female holotype was obtained. Although the area was visited a number of times thereafter and extensively collected, no other adults were found, and no specimens were found on anything but *Purshia*, where they were remarkably concealed. They characteristically posed at the tips of the branches, nearly always in the tops of the brush rather than on the lower limbs.

Seasonal Occurrence. The sketchy data show that nymphs were first collected on June 22 and were found as late as July 16. The adult male was collected on July 16, the female on October 14. The insect is present as adults throughout the summer.

Localities Represented. Specimens examined (nymphs and adults): 18.

Study TCB, 16 nymphs, June 22 to July 16; 1 male, July 16; 1 female, October 14, all on *Purshia glandulosa*.

Additional Remarks. This form was at first considered to be *Insara elegans consuetipes*, the western form of *elegans*, but if *consuetipes* is so completely immaculate throughout its range then the present form would have to be considered as the third subspecies.

Insara covilleae Rehn and Hebard

(Figures 69, 70, 74, 75; Table 45, Map 22)

1914. *Insara covilleae* Rehn and Hebard, Trans. Amer. Entom. Soc., XL, p. 85.

Distinctive Features. Pronotum extremely sellate for the group, differing from the previous species in that respect. Otherwise generally resembling the previous species except for the color pattern and markings which are extremely different. The female ovipositor is shown in Figure 74; the male terminal abdominal appendages are shown in Figure 75.

Coloration. Tegmina green, conspicuously marked with a series of five large spots, white or pale greenish in color, on the dorso-lateral margin, followed distally by a narrow line, less distinct than other markings and proximally with a long line of the same color; otherwise beautifully marked with brown; pronotum bordered with white dorsally and on lateral lobes, brown markings on metazona, and lateral lobes (less distinct). Fourth abdominal tergite with brown

FIG. 71

FIG. 72

FIG. 73

Figs. 71-73 *Insara elegans maculata*. 71, female allotype, apex of abdomen and ovipositor, lateral view. 72, male holotype, pronotum and proximal tegmina showing stridulating mechanism, dorsal view. 73, male holotype, apex of abdomen, dorso-lateral view.

FIG. 74

FIG. 75

Figs. 74-75. *Insara covilleae*. 74, female, apex of abdomen and ovipositor, lateral view. 75, male, apex of abdomen, dorso-lateral view.

and white markings, abdomen otherwise spotted with minute purplish dots. Tibiae presenting an annulate appearance with a subdistal light spot, slightly narrower than the proximal dark spot; caudal femora with subdistal light area around entire appendage.

The species is marked with the same contrasting colors as *Bootettix punctatus* (Scudder), but is more easily seen in its habitat.

Distribution. The species is absolutely and completely limited to the creosote bush, *Larrea divaricata,* although, according to the original description the distribution of *Larrea* is greater than that of *Insara covilleae.*

This species, described from Tumamoc Hill, Tucson Mountains, Pima Co., Arizona, extends from "Lordsburg, New Mexico, westward through the desert portions of Southern Arizona, northward to Lincoln Co., Nevada near Lyons, California and in California as far north as Lyons and the Inyo Mountains and as far west as Cottonwod Station in the Mojave Desert and Palm Springs on the Western edge of the Colorado Desert. Southward distribution in Mexico unknown." (Rehn and Hebard, 1914).

At the Nevada Test Site it was found wherever *Larrea* was present.

In addition to the above distribution, the species is now definitely known from Washington County, Utah, the northeastern distributional limit.

Habitats. The insect can best be collected by sweeping the terminal clusters of leaflets of *Larrea.* Differing from *Bootettix,* the other completely creosote bush restricted orthopteran, *Insara covilleae* will frequently fly when disturbed. Although their alar ability is remarkable they generally fly only onto an adjacent *Larrea,* flying seldom more than forty or fifty feet, but on occasion farther. They can be spotted visually, but are difficult to collect without a net.

Seasonal Occurrence. Nymphs were collected from June 15 to mid-August; adults were found from early July to October 1. Most of the adults were collected in July.

Localities Represented. Specimens examined (nymphs and adults): 47.

Study 10D, 3 specimens, July 19.

Studies 5A and 5CQ, 41 specimens, June 15 to October 1.

Study JA, 3 specimens, June 24 to August 21.

Genus *Arethaea* Stål

1876. *Arethaea* Stål, Bihang Svenska Akad., IV (5), p. 55.

Arethaea brevicauda (Scudder)

(Figures 66, 67, 76; Table 46; Map 23)

1900. *Dichopetala brevicauda* Scudder, Canad. Entomologist, XXXII, p. 331.

Distinctive Features. A small, light green species, with very long slender legs. The males are fully winged, the females with reduced alar

Table 45. Size variation of *Insara covilleae.*

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur	Wings Projecting Beyond Tegmen	Female Ovipositor
♂, 5CQ, July 13, 1961	15.6	3.7	21.9	15.5	2.2	3.1	
♂, 5CQ, July 13, 1961	15.0	3.4	20.4	13.6		3.3	
♂, 5CQ, July 13, 1961	15.0	3.3	22.1	15.3		4.1	
♂, type (Rehn & Hebard)	15.4	3.7	24.0	16.8			
♀, 5CQ, July 13, 1961	18.2	3.8	25.7	17.5	2.2	4.3	5.0
♀, 5CQ, July 13, 1961	15.3	3.2	24.8	17.3	2.2	2.9	
♀, 5A, July 14, 1961	19.1	3.8	23.1	17.1	1.9	4.0	5.1
♀, 5A, July 14, 1961	16.8	3.3	22.8	15.1	2.0	3.7	
♀, allotype (Rehn & Hebard)	17.4	4.0	25.7	18.1			5.4

appendages, much shorter than pronotum. The male tegmina has the stridulating field very strongly and narrowly produced at apex of stridulating vein, as in Figure 76, with the production at apex not equal to the width of the remaining portion of the field. The marginal field of the tegmina is normal. The caudal margin of the pronotal disk is never sharply acute; the lateral lobes with the area of convex callosity sometimes inflated.

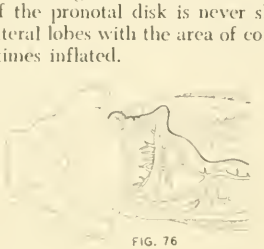


FIG. 76

Fig. 76. *Arethaea brevicauda*, male, pronotum and proximal tegmina showing stridulating mechanism, dorsal view.

Coloration. This insect is unicolorous, light green, and resembles the vegetation upon which it is found.

Distribution. The type locality is Cahon Pass, California. The species is found only in southern California through southern Nevada to Crestline, near the Utah state line. At the Nevada Test Site it was found in only two widely separated localities.

Habitats. These insects are difficult to observe in their habitats of grasses or other low plants. The only male record from the Nevada Test Site was found on *Lycium pallidum*. The vegetation from which the female was taken was not recorded. This area, however, is all *Larrea-Franseria*. LaRivers (1948) reported these insects "associated with *Insara covilleae* and more abundant, being attracted to lights at night in large numbers .... During the day, specimens were found hiding in the cooler depths of such plants as the omnipresent *Larrea divaricata*, *Krameria canescens*, *Prosopis juliflora* and *Acacia greggi*."

Seasonal Occurrence. There is no definite seasonal occurrence from the scant data. The two adults were collected on June 2 and July 15. No nymphs were collected.

Localities Represented. Specimens examined (adults): 2.

Study 5A, 1 male, June 20, on *Lycium pallidum*.

Forty Mile Canyon, 1 female, July 15, no record of the vegetation upon which the specimen was taken.

Table 46. Size variation of *Arethaea brevicauda*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur	Wings Projecting Beyond Tegmen
♂, 5A, June 20, 1961	15.2	3.0	18.8	20.5	1.4	9.5
♀, 40 Mile Canyon, July 15, 1960	14.3[14]	4.0	3.1	21.7	1.7	0.0

Subfamily TETTIGONIINAE

Key to the Genera of TETTIGONIINAE[15]

1. Wings non-functional, much shorter than pronotum (Fig. 77), not visible beyond the pronotum in females ..... *Atelophus* Scudder
   Wings functional, longer than abdomen 2

2. Prosternum armed with a pair of spines (Fig. 78); hind femora armed below on apical half with several distinct spines (Fig. 79) ..... *Capnobotes* Scudder
   Prosternum unarmed; hind femora unarmed below ..... *Anoplodusa* Caudell

[14]Female abdomen obviously shrunken.

[15]*Aglaothorax armiger* Rehn and Hebard was described from the tree yucca (*Yucca brevifolia*), the type locality being Lee Canyon, Nevada, not far from the Nevada Test Site. This species was not collected at the test site, however. This shield-back katydid can be distinguished from the other members of the subfamily by its very large pronotum, its wingless condition, and the cerci of the male, which are without internal hooks.

FIG. 77

FIG. 78

FIG. 79

Figs. 77-79. 77, *Ateloplus luteus*, male, pronotum and tegmina, dorsal view. 78, *Capnobotes fuliginosus*, male, prosternum showing spines, cephalo-ventral view. 79, *C. fuliginosus*, female, caudal femur, lateral view.

Key to the Species of *Capnobotes*

Larger, at least 60 mm. total length; last dorsal segment of abdomen deeply divided apically, the angles forming attenuated prolongations extending over the epiproct, almost or quite reaching the tip (Fig. 80); wings rather uniformly and deeply fuliginous ..... *C. fuliginosus* (Thomas)

Smaller, under 50 mm. total length; last dorsal segment of abdomen less deeply divided apically, the angles forming prolongations scarcely exceeding the middle of the epiproct; wings less fuliginous, at least in the posterior field ..... *C. occidentalis* (Thomas)

Genus *Capnobotes* Scudder

1897 *Capnobotes* Scudder, Canad. Entomologist, XXIX, p. 73.

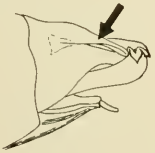


FIG. 80

Fig. 80. *C. fuliginosus*, male, apex of abdomen, dorsolateral view.

Capnobotes fuliginosus (Thomas)

(Figures 64, 78-80; Table 47; Map 23)

1872. *Locusta fuliginosa* Thomas, Ann. Rept. U. S. Geol. Surv. Terr., V, p. 443.

Distinctive Features. A very large species, the total length, including the tegmina and wings, at least 60 mm. The pronotum is large, produced over the base of the abdomen. The tegmina and wings are fully developed, extending far beyond the tip of the abdomen in both sexes. The long, narrow cerci of the male have two apical internal hooks. The terminal abdomen appendages of the male are shown in Figure 80. The ovipositor of the female is distinctly shorter than the hind femora.

Coloration. The basic body color is mottled gray, brown, or occasionally greenish, or brownish mottled with gray. The tegmina have the same general body color and the wings are uniformly and deeply fuliginous, darker on the major veins.

Distribution. This species ranges from California, through Nevada and Utah, into Arizona and Mexico. At the Nevada Test Site it was found widely distributed throughout many of the study areas.

Habitats. This thamnophilous species appears to be more nocturnal than diurnal in habit and is often attracted to lights. At the Nevada Test

Table 47. Size variation of *Capnobotes fuliginosus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♂, MD, July 13, 1961	33.6	7.8	54.1	30.0	3.6	
♂, 5E, June 17, 1961	33.6	7.2	54.0	32.7	3.5	
♀, MD, June 14, 1961	52.5[16]	6.5	54.1	30.4	3.4	29.4
♀, 5E, June 17, 1961	58.1[16]	7.4	62.6	31.8	3.5	27.4

[16]The length of the body includes the very long, sword-shaped ovipositor.

Site they were quite regularly found around the lights and often found inside the buildings that had been lighted and left open at night. They frequently fly for extended periods around the higher lights. They are wary insects during the day and can be found hiding in some of the dense shrubbery. The host plant varies according to the desert habitat. A number of observations were made of this insect, during the day, sitting near the top of a large shrub, such as *Larrea* or *Atriplex*, with the head downward. When disturbed they jump into the center of the bush and frequently escape.

When annoyed the insect often raises its tegmina and wings over its back in a defiant attitude, and if not handled properly will inflict a severe bite on the handler. This is one of the few species of Orthoptera found at the Nevada Test Site that will attempt to bite.

They are at least partially predacious on other insects.

Seasonal Occurrence. Nymphs were collected as early as March 23 and well into the month of June. The adults first appeared on May 27 and were present until, at least, July 27. They were most numerous during the month of June.

Localities Represented. Specimens examined (nymphs and adults): 30.

Study TA, 3 nymphs and adults, March 23 to June 23, probably on *Artemisia tridentata*.

Study 10D, 3 adults, July 12, on *Coleogyne ramosissima*.

Area 1 (studies 1B, 1G), 3 adults, June 16 to June 26, on *Atriplex canescens*.

Study 5A, 1 adult, July 18, on *Larrea divaricata*.

Study 5E, 2 adults, June 17, on *Lycium pallidum*.

Mixed plant communities (studies JA, CBA), 5 nymphs and adults, June 14 to July 27, on *Atriplex canescens* and *Larrea divaricata*.

Area MD, Mercury campsite, 3 adults, June 14 to July 13, attracted to lights. This is a small percentage of the total specimens observed flying about the lights during this period of time.

Study CM, Cane Springs, 7 adults, June 15 to June 20, on *Atriplex canescens*.

Miscellaneous collecting in rocky areas, studies not identified, 3 adults, vegetation not recorded.

Capnobotes occidentalis (Thomas)

(Table 48; Map 23)

1872. *Locusta occidentalis* Thomas, Ann. Rept. U. S. Geol. Surv. Terr., V, p. 444.

Established Synonomy. *Capnobotes occidentalis viridis* Cockerell.

Comparative Features. The species is similar to *fuliginosus*, but differs from that species by lacking the dark hind wings, the much smaller size, and the longer ovipositor in the female. The male cercus is apically armed with a short internal spine with a large subapical internal prong proximally.

Coloration. The species occurs as two distinct phases, brown or green, described in the literature as different subspecies. They should not be recognized as distinct races, however, and the green phase (*viridis*) is synonomized. The brown phase is mottled with flecks of white, especially on the tegmina; the green phase less maculate but with distinct pronotal markings of tan and green.

The only specimen collected at the Nevada Test Site is representative of the green phase.

Distribution. This is a Great Basin species found in the desert and juniper-pinyon areas of Utah, northern Arizona, Nevada, California, New Mexico, and southern Idaho. It is represented from the Nevada Test Site by one subadult female, with undeveloped tegmina and wings.

Habitats. Tinkham (1944) listed juniper as the only host of the species. LaRivers (1948) reported it as common to sagebrush in Nevada, with one specimen being taken on pinyon pine. He also reported the green phase on "two species of introduced weed, *Salsola kali tenuifolia* and

Table 48. Measurements of *Capnobotes occidentalis*.

	Length Body	Length Pronotum	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♀, 12A, June 26, subadult	48.1[17]	7.3	22.5	3.0	25.2

[17]The length of the body includes the very long, sword-shaped ovipositor.

an unidentified chenopodiac, whose vivid greens the insect matched well."

The one specimen from the Nevada Test Site was swept from *Oryzopsis hymenoides*.

Seasonal Occurrence. The only specimen, a subadult female, was collected on June 26.

Localities Represented. Specimens examined (subadult): 1.

Study 12A, Rainier Mesa disturbed area, 1 subadult female, June 26. This is a pinyon-juniper area, but most of the trees have been destroyed as a result of an atomic explosion.

Genus *Anoplodusa* Caudell

1907. *Anoplodusa* Caudell, Proc. U. S. Nat. Mus., XXXII, p. 319, fig. 25.

Anoplodusa arizonensis (Rehn)

(Figures 60, 63; Table 49; Map 24)

1904. *Drymadusa arizonensis* Rehn, Proc. Acad. Nat. Sci. Philadelphia, LVI, p. 573.

Distinctive Features. The wings are very long as in the genus *Capnobotes*. The most distinctive features, however, are given under "Coloration."

Coloration. Greenish, occasionally slightly buff especially in dried condition, with ivory-white markings on the entire body; pronotum, especially the margins of the lateral lobes and the margins of metazona marked with white, yellowish in pinned specimens; pronotum also marked with brown. Tegmina of both sexes green, with three distinct, or sometimes somewhat indistinct, rows of large circular nacreous spots, the stridulation field of the male tegmen reddish brown. Hind wings transparent.

Distribution. A member of the Lower Sonoran life zone, this species is found from the Mohave Desert in California to Arizona. At the Nevada Test Site it is limited in distribution to the Lower Sonoran life zone, the marginal areas of Frenchman and Yucca playas.

Habitats. *Anoplodusa arizonensis* is adaptively colored to the creosote bush, *Larrea divaricata*, but it is not restricted to that shrub. It has been observed on *Dalea polyadenia, Franseria dumosa* and *Grayia spinosa*.

The insect is apparently limited to *Larrea* as a source of food and is probably not carnivorous in nature, as are its relatives, *Capnobotes*. It will, however, attempt to bite when handled and can produce a rather severe bite.

Although Tinkham's specimens (Tinkham 1942) were collected at night, at the Nevada Test Site the species was found only during the day, and searches at night failed to reveal its presence. This is perhaps due to its scarcity and the large expanses of *Larrea*, making it difficult to encounter.

Its very large size makes it readily discernible in a shrub upon which it rests. All the specimens were taken as a result of this visual study. It is a remarkable flier and after disturbance has flown for nearly 200 yards. It apparently does not rely upon concealment for escape, but upon the powers of flight. When disturbed it immediately flies at about 15 feet altitude in a straight line, sometimes until nearly out of sight, and immediately drops into another shrub. A second and third flight is often encountered in an attempt to capture specimens. Accordingly, it is one of the most difficult orthopterans to collect. One specimen was first observed flying in small circles about one hundred feet from the ground. As soon as the author got out of the car it immediately flew in a straight line at that approximate altitude until it had completely disappeared from sight.

Seasonal Occurrence. Tinkham's report states that this is an early spring form, persisting until late summer. He reported specimens having

Table 49. Size variation of *Anoplodusa arizonensis*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♂, 5A, July 14, 1961	30.6	6.8	42.8	25.8	3.1	
♀, 5CQ, July 10, 1961	51.2	6.6	45.8	25.5	2.9	27.1
♀, 1BD20, July 12, 1961	50.2	6.5	44.9	25.5	2.9	24.9
♀, 10D, July 13, 1961	47.6	5.7	41.5	23.7	2.7	23.6
♀, 5A, July 11, 1961	54.9	5.1	46.6	25.5	3.2	26.2
♀, 1C, June 19, 1961	41.9	5.5	40.6	21.7	2.5	22.8

been collected as adults from April to early August. "Since the eggs are laid in late July or early August at about the time the desert rains commence, it appears highly probable that the ova hatch in the fall and the nymphs develop during the fall and late winter to mature in the early spring. This assumption is based on knowledge of other Orthoptera in the region." Nothing has been published on the habits of nymphs, to date, however, and no discoveries were made in the present study to reveal their habits. Specimens from the Nevada Test Site were collected during June and July.

Localities Represented. Specimens examined (adults): 15.

Study 1BD20, 1 adult female, July 12, on *Grayia spinosa*.

Study 1G, 1 adult female, June 19, on *Larrea divaricata*.

Study 4A, 1 adult, June 19.

Studies 5A and 5CQ, 11 adults, June 15 to July 14, on *L. divaricata* and *Franseria dumosa*.

Study 10D, 1 adult female, July 13, on *L. divaricata*.

Genus *Ateloplus* Scudder

1894. *Ateloplus* Scudder, Canad. Entomologist, XXVI, pp. 179, 182.

Ateloplus luteus Caudell

(Figure 77; Table 50; Map 24)

1907. *Ateloplus luteus* Caudell, Proc. U. S. Nat. Museum, XXXII, p. 373.

Distinctive Features. Pronotum short, the posterior margin truncate, the lateral lobes shallow. Male tegmina visible and extending beyond pronotum; female tegmina not extending beyond pronotum.

Morphological Variation. This is one of the most variable species at the Nevada Test Site. An obvious variation from the typical condition is the spined nature of the fore tibiae. In the specimens from the test site there are three spines instead of the usual one.

Coloration. In the series of specimens from the Nevada Test Site there is a remarkable difference in coloration and pattern. The females are tan with longitudinal stripes on the pronotum, while only one male is suggestive of this marking. Generally the specimens have one medio-dorsal dark stripe extending from the anterior margin of the pronotum to the tip of the abdomen, but the stripe may be partially or completely absent. The caudal tibiae in typical specimens are light bluish-green. The veins of the male tegmina are light, with dark cells.

Distribution. The species is limited in distribution to California and Nevada. At the Nevada Test Site it was widely distributed and found in many collecting areas.

Habitats. These insects are frequently swept from low shrubs at the Nevada Test Site and were occasionally found on upright stakes used as markers. Helfer (1963) reported that they are nocturnal; however, most specimens at the test site were collected during the day. A few specimens were found in can traps, but whether this was the result of a nocturnal or diurnal movement could not be determined.

Seasonal Occurrence. Nymphs and adults were both collected in May — the nymphs from May 10 into July; the adults from May 12 to September 4. The species was most abundant during June and July.

Localities Represented. Specimens examined (nymphs and adults): 36.

Table 50. Size variation of *Ateloplus luteus*.

	Length Body	Length Pronotum	Breadth Pronotum	Depth Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♂, 5A, June 20, 1961	16.9	5.6	4.6	3.6	1.2	14.6	2.9	
♂, 1G, July 12, 1961	19.4	5.1	4.9	3.7	0.8	14.9	2.9	
♂, 10D, July 19, 1961	19.2	5.5	4.6	3.0	1.1	13.6	2.8	
♂, 5A, July 3, 1961	21.6	6.0			1.4	13.4	3.1	
♀, 10DA5, July 17, 1961	23.2	4.4	4.1	2.7		12.3	2.8	8.7
♀, 5CQ, July 18, 1961	25.5	6.6	5.9	3.6		17.2	3.2	13.9
♀, ECB, August 11, 1961	31.2	5.1	4.6	3.3		17.5	3.4	11.4

Studies 1B and 1G, 5 specimens, May 10 to August 9.

Studies 5A and 5CQ, 12 specimens, May 12 to July 18.

Study 5E, 3 specimens, May 17 to June 6.

Study 6A, 3 specimens, June 18 to August 14.

Study 10D, 5 specimens, June 21 to September 4.

Study CBA, 1 specimen, June 13.

Study JA, 1 specimen, June 3.

Studies TA, Midvalley, and ECB, Target Rock area, 6 specimens, June 22 to August 18.

Additional Remarks. Because of the diversity of the species, specimens were submitted to Dr. A. B. Gurney of the U. S. National Museum, who made the determination.

One female (ECB, August 11, 1961) is atypical with narrower pronotum and reduced spines on the ventral margins of the caudal femora. It perhaps is a morphological aberrant, or may represent an undescribed group.

Family Gryllacrididae

Representatives of the Gryllacrididae at the Nevada Test Site belong to two subfamilies, each distinct from the other. They all have four-segmented tarsi, the tegmina and wings are completely absent, and the general features are more or less grylloid. The female ovipositor is compressed, of the tettigonioid type; the male cerci are commonly elongate, flexible, and covered with long, erect tactile hairs (Hubbell 1936).

Subfamily Stenopelmatinae

The members of this group are called Jerusalem crickets or sand crickets. They are completely wingless with strong, spiny legs, and a large inflated head with powerful jaws, with which they can bite severely. They have a reputation for being actually poisonous. They live in the soil or under rocks and other objects and are able to burrow rather rapidly. Their food consists, to a large extent, of other insects. The family is represented by only one species at the Nevada Test Site.

Genus *Stenopelmatus* Burmeister

1838. *Stenopelmatus* Burmeister, Handb. Ent. II, p. 720.

Stenopelmatus fuscus Haldeman

(Figure 81; Table 51; Map 25)

1853. *Stenopelmatus fuscus* Haldeman, Appendix C in Stansbury, Exploration of Great Salt Lake, p. 372.

Established Synonomy. *Stenopelmatus cephalotes* Walker; *Stenopelmatus fasciatus* Thomas; *Stenopelmatus oculatus* Scudder; *Stenopelmatus hydrocephalus* Bruner; *Stenopelmatus*

Key to the Subfamilies of Gryllacrididae

Antennal bases widely separated, by more than twice the length of the eye (Fig. 81); tarsi with pulvilli; head large; cephalic coxa unarmed laterad ..... Subfamily Stenopelmatinae, page 91

Antennal bases very close together (Fig. 82); tarsi without pulvilli; head smaller; cephalic margin of cephalic coxa armed with a spine (Fig. 83) ..... Subfamily Rhaphidophorinae, page 94

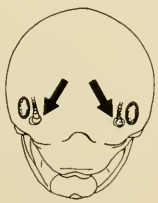
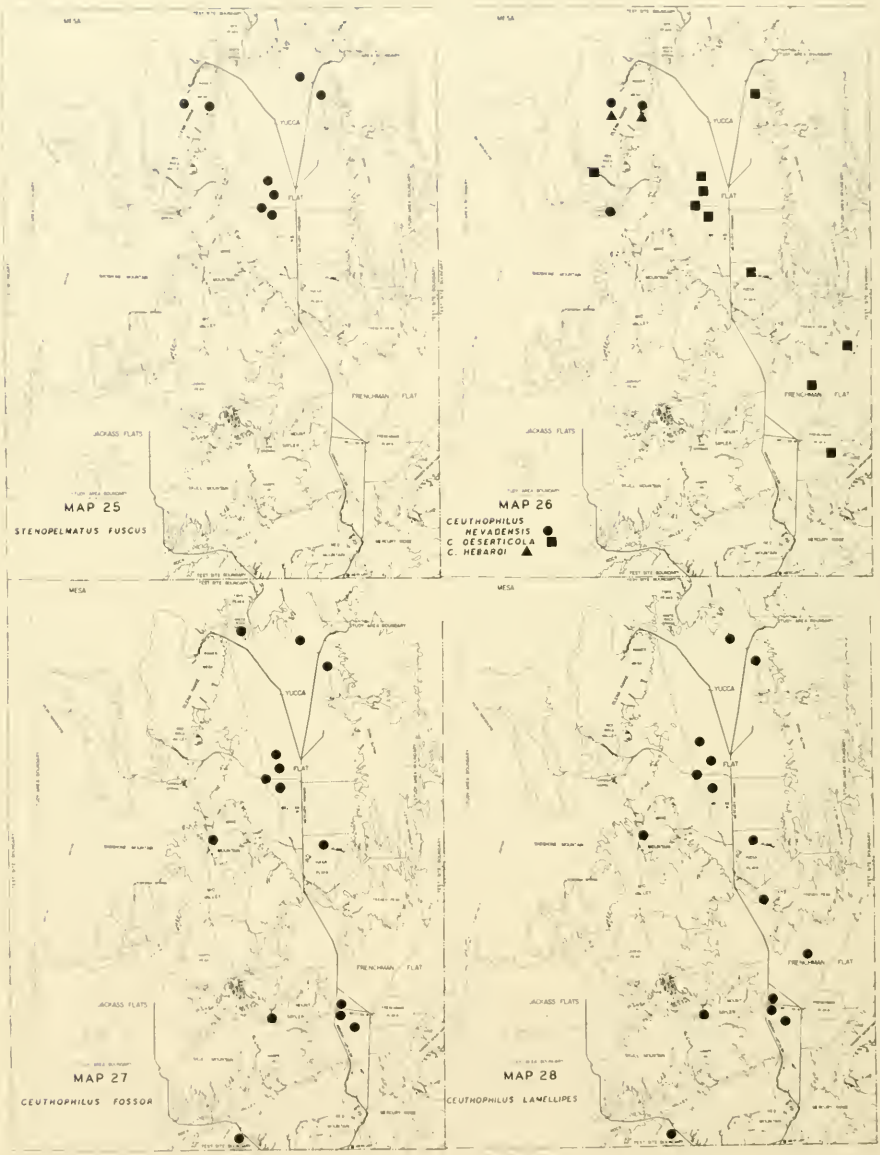


FIG. 81

FIG. 82

FIG. 83

Figs. 81-83. 81, *Stenopelmatus fuscus*, male, head, facial view. 82, *Ceuthophilus fossor*, female, head, facial view. 83, *C. fossor*, female, cephalic coxa showing spine


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 25
STENOPELMATUS FUSCUS
MAP 26
CEUTHOPHILUS
NEVADENSIS
C. DESERTICOLA
C. HEBARDI
MAP 27
CEUTHOPHILUS FOSSOR
MAP 28
CEUTHOPHILUS LAMELLIPES

comanchus Saussure and Pictet; *Stenopelmatus terrenus* Rehn (?).

Distinctive Features. The most striking character of the species is the very large head, enlarged out of all proportions to the body, particularly in the occipital region. This character alone is sufficient for the recognition of the species. In addition, the characters given in the key can be used to distinguish it from its near relatives.

Morphological Variation. This species was described early in the work on the Orthoptera and has been known by a number of common names as well as having been described by different workers. The synonomy, of course, indicates the variable characters of the species.

The genital structures have been most useful in studies on orthopteran speciation. However, differential genitalic characters apparently do not exist for this group. According to Hebard (1916) the male has a small stout incurved chitinous hook on each side of the epiproct just proximad of the cerci. The epiproct and subgenital plates show no other specialization and are in general similar. The stuctures within the genital chamber are soft, unmodified and shrivel in drying. The female epiproct and subgenital plates show no specialization. The ovipositor is short and simple.

Because of these genitalic characters it is very difficult to separate the adults from the subadults, or individuals in the last instars preceding maturity. The complete absence of wings leaves the abdomen and the genital structures as being the criteria for determining adult specimens, and both the external and internal genital structures are unspecialized. The only apparent difference, then, is the general heaviness and solidity of the limbs of the true adult.

See "Additional Remarks" for further comments.

Coloration. The general body color of the insect is yellowish marked with dark brown. Some specimens show a particular barring on the abdomen. In most of the heavily spined species of orthopterans the spines are very dark. This is particularly true with *Stenopelmatus*, and the very robust insect appears light yellow or tan and dark brown, almost black. The dorsal surfaces are very shiny.

Distribution. This species has a wide distribution in the United States from the eastern edge of the Great Plains to the Sierras of western North America. The specimens from the Nevada Test Site represent collections from near its western limits. Here, it is well distributed throughout most of the sandy areas of the test site, particularly on and around Yucca Flat and on Rainier Mesa.

Habitats. This subterranean insect is largely nocturnal. Individuals can frequently be found wandering about the desert in late afternoon, especially when the humidity is relatively high and the temperatures lower. Because of its nocturnal habits, most of the specimens collected from the Nevada Test Site were taken in the can traps. A few specimens were picked up from the ground or as a result of over-turning rocks in search for fossorial orthopterans.

Seasonal Occurrence. Nymphs were collected as early as March 10 and were still present in September. Adults were first collected in April and were taken as late as November 21. They were collected throughout most of the year, but were most numerous in June and July. An increased number of specimens were again found in May, August, and October. For some reason fewer specimens were collected during the month of September. The series collected represents all ages, from first nymphal instars to adults.

Table 51. Size variation of *Stenopelmatus fuscus*.

	Length Body	Length Pronotum	Length Caudal Femur	Breadth Caudal Femur
♂, 1GB7, October 2, 1961	33.3	7.2	13.1	4.7
♂, 1FA5, August 2, 1961	31.0	6.8	11.5	4.3
♀, 12EC10, October 23, 1961	30.6	6.1	10.2	3.9
♀, 12EC2, October 23, 1961	33.7	6.3	10.7	4.1
♀, 1BD20, October 24, 1961	35.4	6.9	12.7	4.4

Localities Represented. Specimens examined (nymphs and adults): 126.

Studies 1B, 1C, and 4A (all in *Grayia-Lycium* communities), 71 specimens March 10 to November 21.

Study 1F, 2 specimens, August 2 and November 1.

Study 10D, 1 specimen, July 13.

Study 10S, 36 specimens, June 19 to July 5. (This study area was opened late in the research, and a complete evaluation of the area has not been made.)

Area 10, miscellaneous collections, 1 specimen, September 16.

Studies 12A and 12E, Rainier Mesa, 12 specimens, June 15 to October 27. More specimens were collected in the undisturbed area than the disturbed area.

Additional Remarks. Some variation exists within the confines of the Nevada Test Site. Those specimens taken at higher elevations, Area 12 on Rainier Mesa, differ somewhat in the subgenital plate, in the ovipositors, and by the pile on the body, which latter difference could be a result of activity and normal wear. In these specimens the dorsal valves of the female ovipositor are slightly less than twice the length of the ventral valves and the subgenital plate is rounded. In the specimens taken at lower elevations the dorsal valves are only one-fifth longer than the dorsal valves and the subgenital plate is acute.

Those specimens from the lower elevations are very hairy compared to the practically glabrous appearance of the others.

If genitalic characters could be relied upon it might mean a separation of these two populations. In the absence of such characters it might be possible to carry out breeding experiments to see whether or not they are distinct or the same. Surely lesser differences exist in the genus *Ceuthophilus*, which group has highly developed genitalic structures and species can be separated on this basis. A complete revision of the genus *Stenopelmatus* may warrant separation of these forms.

Subfamily Rhaphidophorinae

The members of this group are commonly known as the cave or camel crickets. They are tan to brown, wingless, with curved or humped body, rather than flattened as in the true crickets. Although very common they are not often noticed, since they are nocturnal in habit or live in caves or other cavities in the ground.

The system of special can traps used in the studies at the Nevada Test Site resulted in a far larger collection of these crickets than any other orthopteran group. After extensive observations throughout this area during all seasons of the year it has been determined that this group is the most common of all the Orthoptera.

The subfamily is represented by two genera, the *Pristoceuthophilus* being found only at higher elevations.

Key to the Genera of Rhaphidophorinae

Male with styles (Fig. 84); ventral ovipositor valves of female armed distad with crenulations or low serrations (Fig. 85); tarsal claw with a distinct ventro-proximal sensory seta (Fig. 86). ..... *Pristoceuthophilus* Rehn

Male without styles; ventral ovipositor valves of female armed distad with four (in Nevada Test Site specimens) triangular or acicular teeth in addition to the terminal decurved hook-like apex (Fig. 87); tarsal claws without sensory setae ..... *Ceuthophilus* Scudder

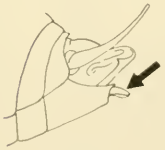


FIG. 84

FIG. 85

FIG. 86

FIG. 87

Figs. 84-87. *Pristoceuthophilus pacificus*. 84, male, apex of abdomen, dorso-lateral view. 85, female, distal valves of ovipositor, lateral view. 86, male, distal segment of caudal tarsus showing claws and sensory setae. 87, *Ceuthophilus lamellipes*, female, distal valves of ovipositor, lateral view.

Genus *Ceuthophilus* Scudder

1862. *Ceuthophilus* Scudder, Canadian Nat. & Geol., VII, p. 284.

Key to the Species of *Ceuthophilus*
(Adapted from Hubbell, 1936)

1. Subgenital plate of male divided into lateral halves by a percurrent median fold or sulcus (Fig. 88); ovipositor of female very long, the ovipositor/pronotum ratio 2.0 or more. Form less compact; legs longer and more slender, caudal femur rhaphidophoroid, spines of ventrocephalic carina fewer and separated by distinct intervals .... *C. nevadensis* Barnum, new species

Subgenital plate of male with proximal portion undivided by a median sulcus, but distolateral portions often prolonged and separated by a cleft or notch extending in from

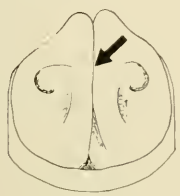


FIG. 88

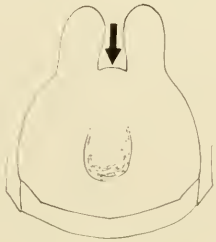


FIG. 89

FIG. 90

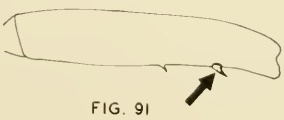


FIG. 91

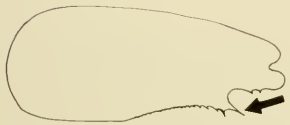


FIG. 92

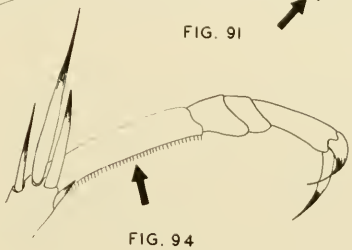


FIG. 94

FIG. 95

FIG. 93

FIG. 97

FIG. 96

FIG. 98

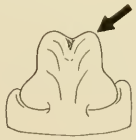


FIG. 99

Figs. 88-99. 88, *C. nevadensis,* male holotype, subgenital plate, caudal view. 89, *C. fossor,* male, subgenital plate, caudal view. 90, *C. fossor,* male, cephalic margin of cephalic femur, lateral view. 91, *C. hebardi,* male, cephalic margin of cephalic femur, lateral view. 92, *lamellipes,* male, cephalic margin of caudal femur, lateral view. 93, *C. lamellipes,* female, distal end of cephalic margin of caudal femur, lateral view. 94, *C. deserticola,* male holotype, caudal tarsus, lateral view. 95, *C. deserticola,* distal abdominal tergites, dorsal vew. 96, *C. deserticola,* male holotype, subgenital plate, caudal view. 97, *C. hebardi,* male, caudal tarsus, lateral view. 98, *C. hebardi,* male, distal abdominal tergites, dorsal view. 99, *C. hebardi,* male, subgenital plate, caudal view.

apex of free margin (Fig. 89); ovipositor of female short, the ovipositor/pronotum ratio less than 2.0. Form compact, robust, with short, stout legs; caudal femur grylloid, its ventrocephalic carina usually with numerous, closely-spaced denticulations; often unicolorous or nearly so 2

2. Ventrocephalic carina of cephalic femur ornamented with a row of numerous nodules or denticulations in addition to the movable distal spurs (Fig. 90) ..... *C. fossor* Hubbell

Ventrocephalic carina of cephalic femur not nodulose, either unarmed or bearing one or more movable spurs (Fig. 91) 3

3. Ventral carinae of caudal femur strongly laminate-explanate, breadth of carinae increasing distad, each terminated just proximad of base of genicular lobes by deep excision of margin, end of lamella forming an acute trigonal process; margins of carinae closely denticulate (figs. 92, 93) ..... *C. lamellipes* Rehn

Ventral carinae of caudal femur not as in alternative 4

4. Ventral carina of caudal metatarsus armed with a row of short, bristle-like setae extending all the way to apex (Fig. 94); 8th abdominal tergite of male not produced caudad, the 9th tergite being much the wider (Fig. 95); subgenital plate of male suborbicular, separated for most of its distance (but never proximally) by a median sulcus (Fig. 96) ..... *C. deserticola* Barnum, new species

Ventral carina of caudal metatarsus glabrous except for a proximal group of setae (Fig. 97); 8th abdominal tergite of male greatly produced caudad, concealing most of the 9th tergite (Fig. 98); subgenital plate of male elongate, terminating in a pair of large, widely separated rounded protuberances (Fig. 99) ..... *C. hebardi* Hubbell

The descriptions of the species of *Ceuthophilus*, as indicated by indices and measurements, are the same as those employed by Hubbell (1936) in his monographic revision of the genus. All measurements were made with a micrometer in one ocular of a binocular microscope. In cases of doubt as to the identification of the species the male internal genital structures and/or subgenital plate should be compared with the indicated drawings.

The worker may find it difficult to separate the adults from the larger nymphs or subadults. The females of the species can be told by the fully developed teeth on the ventral valves of the ovipositor, these being very acicular or at least sharp-tipped in the adult, mere rounded protuberances in the subadult and larger nymphs. The adult males can be told by the sclerotization of the epiphallus (pseudosternite of Hubbell) and associated structures. In the nymphs and subadults these structures are in no way sclerotized.

Ceuthophilus nevadensis Barnum, New Species

(Figures 88, 110-120, Table 52; Map 26)

Holotype Male, Nevada, Nye Co., Nevada Test Site, Study TE (Tippipah Springs), August 24, 1961.

Allotype Female, same locality, July 16, 1961. Both specimens are deposited in the U. S. National Museum.

This species belongs to the subgenus *Ceuthophilus*, *Utahensis* series, and *Paucispinosus* group of Hubbell. Within the group it shows a greater affinity to *C. yavapai* Hubbell, but differs from this and all other species by the form of the terminal abdominal appendages of the male, particularly. In the distribution the species is closely allied to *utahensis* but differs remarkably in the terminal abdominal appendanges of both male and female. Superficially it is perhaps indistinguishable from the closely related species. As is indicated by Hubbell, it is more difficult to distinguish the females.

The general body form is elongate with moderately long, slender legs and short spurs, calcars, and claws.

Description of Holotype Male. Body very elongate and slender, length 16.8 mm. Dorsum, including abdomen, weakly polished, subglabrous with very scattered minute setae. HEAD. Eyes moderate in size, length 0.7 mm., width 0.55 mm.; interocular distance 1.3 mm.; infraocular distance 1.45 mm.; clypeal suture 1.9 mm.; antennae long, approximately two and one-half times body length; distal segment of maxillary palpi 2.2 mm.; fastigium more prominent than expanded mesal margins of an-

tennal fossae, apex noticeably projected, very bluntly rounded, subconical, sparsely setose. THORAX. Pronotal length 3.3 mm., greatest breadth 3.8 mm., depth, in side view 2.4 mm., in dorsal aspect subquadrate, cephalic margin broadly emarginate, caudal margin truncate, ventrolateral margins rather strongly arcuate, slightly projected outward, broadest point just caudad of midlength; mesonotal length 1.7 mm., greatest width 3.8 mm., caudal margin in dorsal aspect broadly convex; metanotal length 1.55 mm., greatest width 3.5 mm., caudal margin in dorsal aspect slightly emarginate. LEGS. Cephalic femur (Figure 117), length 5.5 mm., width 0.8 mm., equal in length and breadth to middle femur, ventrocephalic carina with 1-1 spurs, spur short 0.35 mm. long; middle coxa with dorsocephalic carina not explanate, dorsocephalic angle obtuse, distal angle forming a very blunt projection directed cephalad; middle femur, ventrocephalic carina with 3-3 spurs, ventrocaudal with 2-2 very small spurs. Caudal femur (Fig. 119) moderately elongate and slender, length 11.5 mm., greatest breadth 2.6 mm. occurring at the proximal one-sixth, then gently tapering distad to base of genicular lobes, ventrocephalic carina with 23 somewhat irregularly spaced subequal minute spinulose denticulations on the distal two-thirds of carina, the largest of these being restricted to the distal one-half, ventrocaudal carina with 45 similar but somewhat smaller denticulations, these appearing in one series on caudal side of carina, except for eight minute denticulations on cephalic side of carina in proximal one-half, dorsal denticulations about 40, scattered on distal half of femur, but more restricted to cephalic surface, caudal genicular lobe distinctly spinulose. Caudal tibia straight, 11.6 mm. in length, dorsal spurs (Fig. 120) moderately slender and elongate, subdistal spur of cephalic carina 0.75 mm. long, spurs gently curved, apex minutely hooked, dorsal face bicarinate, outer face sparsely setose, the setae varying on different spurs, spines of carinae variously arranged according to distance between spurs, averaging 13 between proximal tibia and first spur, then averaging 8 between other spurs; subdistal ventral spurs 1-1; calcars short, dorsocephalic calcar 0.75 mm. in length, the other calcars being 1.45 mm., 0.6 mm., 0.4 mm. respectively. Metatarsus 2.1 mm. long, 2nd segment of tarsus 0.9 mm. long, 0.5 mm. wide, 4th segment 1.3 mm. long, claws 0.6 mm. long, ventral carina of tarsal segments without setae except a small group at proximal end.

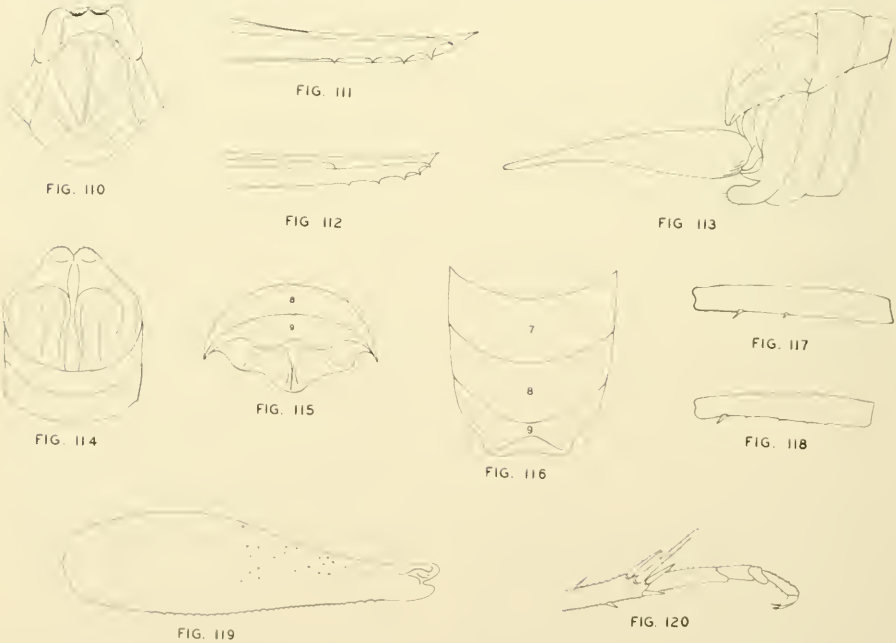
Terminal Abdominal Structures. (Figures 113-116). Dorsocaudal margin of first abdominal tergite slightly concave, of tergite two to six truncate or subtruncate, of seven rounded-angulate, of eight rather strongly produced, the dorsocaudal margin tumid; dorsal surface of ninth tergite greatly produced caudad, abruptly emarginate mesially, very tumid. Epiproct exposed dorsally, the tenth tergite projecting beyond caudal margins of ninth dorso-laterally; epiproct directed ventrad, triangular, margins slightly elevated, straight and convergent to apex. Paraprocts membranous, enlarged, produced beyond epiproct. Supraanal plate a small triangular lobe compressed between paraprocts, apex rounded. Cerci 3.1 mm., originating as a heavy appendage proximally, abruptly expanded to approximately twice the proximal diameter, then gradually tapering to end. Epiphallus (Fig. 110) exposed, projecting dorsad of subgenital plate, heavily sclerotized, rami divergent to dorsum of arch, a straight horizontal bar, cephalic margin turned under arch, junctions of rami and dorsum bearing large conspicuous, erect, laminate auriculae, projected mesially as continuous with dorsum and sub-horizontal to rami, projected ventrad one-half the distance of the sclerotized rami, the auriculae rounded protuberances both ventrad and dorsad. Mesal margins of membranous areas within arch forming two brownish, heavily sclerotized tumid folds with laminate surfaces. Subgenital plate similar to *C. pima*, rather heavily corneous, including distal margin, except a small proximal area on either side of mesal groove, completely divided into lateral halves by a small groove, terminating distally as two rounded lobes.

Description of Allotype Female. General characteristics as given for male holotype. Body length 17.8 mm., including ovipositor, 27.6 mm. HEAD. Eyes, length 0.85 mm., width 0.65 mm., interocular distance 1.4 mm., infraocular distance 1.5 mm., clypeal suture 2.1 mm., distal segment of maxillary palpi 2.3 mm. THORAX. Pronotal length 3.8 mm., greatest breadth 4.6 mm., depth in side view 2.85 mm.; mesonotal length 2.75 mm., greatest breadth 4.8 mm. in dorsal aspect; metanotal length 2.3 mm., greatest breadth 4.4 mm. LEGS. Cephalic femur, length 5.9 mm., breadth 1.1 mm., ventrocephalic carina with 2-3 spurs, the distal spur 0.4 mm. long; middle femur, ventrocephalic carina with 4-3 spurs, ventrocaudal with 1-2 spurs. Caudal femur length 11.9 mm., greatest breadth 3.2 mm., ventrocephalic carina with 29 spinulose denticulations, ventrocaudal carina with 30 denticulations, dorsal denticulations 55. Caudal tibia 12.3 mm. in length, subdistal spur of cephalic carina 0.95 mm. long, spines of carinae averaging as in male;

subdistal ventral spurs 1-1; dorsocephalic calcar 0.4 mm. in length, the other calcars being 0.6 mm., 1.45 mm., 0.75 mm. respectively. Metatarsus 2.1 mm. long, 2nd segment of tarsus 1.05 mm. long, 0.55 mm. wide, 4th segment 1.5 mm. long, claws 0.8 mm. long.

Terminal Abdominal Structures. Cerci 2.3 mm. long, slender, not expanded and modified as in male. Subgenital plate simple. Ovipositor (Figure 111) 10.8 mm. long, gradually tapering throughout, very slightly upturned, dorsal valves terminating in a slender point, sub-aciculate, longer than ventral valves, five aciculate teeth of ventral valves short, separated equidistantly, restricted to the distal one-fifth of valve.

Coloration. Similar to *utahensis* and its related species, the following color description is modified from Hubbell for that species. General impression of dorsum yellowish brown, with weakly contrasted pattern on pronotum and transverse banding on abdomen. Pronotum margined with brown along ventrolateral as well as cephalic and caudal margins, the disk with a pair of admesal brown bands separated by a narrow yellowish line and by a pair of caudal admesal triangles embracing the caudal end of the pair of admesal bands and separated from them by a U-shaped light area connecting the reniform areas of each side, these mottled with brownish spots and lines. Meso- and metanotum largely brownish, with extensive yellowish spots near cephalic margin, leaving the caudal and ventrolateral margins solid brownish. Abdominal tergites margined broadly with brownish, cephalic portions light, giving a transverse-banded appearance which disappears caudad due to crowding of tergites and concealment of paler areas. Caudal femur with usual scalariform pattern indicated by darker brown, the remainder of legs largely without maculations or markings, being unicolorous. All spines, calcars, spurs, and tubercles tipped with darker brown.



Figs. 110-120. *Ceuthophilus nevadensis*. 110, male paratype, epiphallus. 111, female allotype, distal valves of ovipositor, lateral view. 112, female partaype, distal valves of ovipositor, lateral view. 113, male holotype, apex of abdomen, lateral view. 114, male holotype, subgenital plate, caudal view. 115, male holotype, epiproct. 116, male holotype, distal abdominal tergites, dorsal view. 117, male holotype, cephalic margin of cephalic femur, lateral view. 118, male paratype, cephalic margin of cephalic femur, lateral view. 119, male holotype, caudal femur, lateral view. 120, male holotype, caudal tarsus, lateral view.

Variation. Sizes of the minimum, maximum and average of the sexes, as well as the holotype male and allotype female are indicated in the following table. The general remarks of *C. nevadensis* hold true for this species, as well as for all species of *Ceuthophilus*, seemingly. Variations in the spurs of the ventrocephalic carina of the cephalic femur, which count was taken as an indication for the variation of the spinulose condition of the insect, are as follows: the general condition is with two spurs, one larger distal spur and a smaller more proximal spur, this occurring in 70 per cent of the individuals. Twenty per cent of the specimens had only one larger distal spur, and three spurs were least common. One specimen was observed with a series of five spurs, the two distal spurs being large, the three proximal ones minute.

Habitat. This insect is known only from two areas on the Nevada Test Site, in an abandoned tunnel known as Tippipah Springs and in the disturbed area on Rainier Mesa. The tunnel, dug in clay and shale, has many cracks and fissures so that the ceiling frequently sloughs off. It has a perennial water supply, keeping the environment humid and cool, a typical habitat for a cave-dwelling camel cricket. The insects are found on the ceiling of the tunnel, never on the sides, as is typical with other such cavernicolous species, and they escape readily into the cracks and fissures when the beam of light is shined on them. They are never found near the entrance and are not subjected to light from the opening, as they are back in a darkened area of the tunnel. This characteristic has been observed with other species of this group in similar habitats. This species was not found in any of the abandoned mine tunnels in the area and has not been located in any of the caves, perhaps due to the aridity of those areas.

On Rainier Mesa, Study 12A had many large cracks and fissures as a result of an atomic explosion nearby. The insects were collected only in the can traps, probably as a result of their nocturnal movement from the fissures. At this higher altitude the fissures are undoubtedly quite humid, similar to the environment of Tippipah Springs.

Tippipah Springs was visited on only three occasions during the course of this study, one trip in June, July and August. The insects were very numerous at each visit, and no correlation was made according to the appearance of nymphs, adults, or sex. Collections were made as follows at Tippipah Springs:

	June 23, 1961	July 16, 1961	August 24, 1961
♂ Nymphs	7	7	1
♀ Nymphs	8	5	2
♂ Subadults	13	9	3
♀ Subadults	11	17	4
♂ Adults	7	8	9
♀ Adults	7	4	4

During the August trip the nymphs were equally as numerous as the adults but were not collected. A concentrated effort was made to collect adults.

Because of the conditions of the interior of the tunnel with respect to humidity and temperature, the adults, and perhaps the nymphs, could likely be found at any time during the year. This condition has been observed in a similar situation with another species.

Their occurrence on Rainier Mesa has not been completely evaluated. Adults were collected from July 25 to August 24.

Distribution. The present known distribution of this insect is limited to the two areas at the

Table 52. Size variation of *Ceuthophilus nevadensis*.

	Length Eye	Breadth Eye	Interocular Distance	Length Maxillary Palpus	Length Pronotum	Length Cephalic Femur	Length Caudal Femur	Length Caudal Tibia	Length Metatarsus	Length 2d Tarsal Segment	Breadth 2d Tarsal Segment	Length 4th Tarsal Segment	Length Tarsal Claws	Length Ovipositor
♂, Holotype	0.7	0.55	1.3	2.2	3.3	5.5	11.5	11.6	2.1	0.9	0.5	1.3	0.6	
♂, Paratype, Minimum	0.7	0.5	1.2	1.9	2.9	4.4	9.6	10.5	1.9	0.8	0.4	1.2	0.6	
♂, Paratype, Average	0.8	0.57	1.355	2.1	3.34	5.38	11.12	11.88	2.12	0.97	0.495	1.39	0.665	
♂, Paratype, Maximum	0.9	0.65	1.5	2.3	3.7	6.1	12.2	13.0	2.3	1.2	0.6	1.6	0.8	
♀, Allotype	0.85	0.65	1.4	2.3	3.8	5.9	11.9	12.3	2.1	1.05	0.55	1.5	0.8	10.8
♀, Paratype, Minimum	0.8	0.6	1.3	2.1	3.5	5.1	10.7	11.4	2.0	0.9	0.5	1.3	0.7	8.7
♀, Paratype, Average	0.9	0.68	1.48	2.27	3.87	5.66	11.75	12.55	2.15	1.015	0.57	1.44	0.765	9.78
♀, Paratype, Maximum	1.0	0.75	1.6	2.5	4.4	6.0	13.2	13.5	2.3	1.1	0.7	1.6	0.85	10.8

Nevada Test Site. It could conceivably be found in other areas similar to the type locality and Rainier Mesa, but such favorable areas are not common throughout the arid Great Basin.

Localities Represented. Specimens examined (nymphs and adults): 119.

Tippipah Springs (Study TC), 113 specimens: 24 male adults, 15 female adults; 16 male subadults, 28 female subadults; 15 male nymphs, 15 female nymphs, according to the above dates.

Rainier Mesa (Study 12A), 6 adults: 12AC6, 2 females, August 11 and August 24, 1961; 12AC8, 1 male, August 11, 1961; 12AC9, 1 female, August 14, 1961; 12AC10, 2 males, July 25 and August 12, 1961.

Additional Remarks. The holotype male and allotype female, as noted previously, are deposited in the U. S. National Museum. Paratypes are deposited at the Philadelphia Academy of Natural Sciences; the California Academy of Sciences; the Museum of Zoology, University of Michigan; Brigham Young University; and the author's collection.

Ceuthophilus deserticola Barnum
New Species

(Figures 94-96, 121-129; Tables 53, 54; Map 26)

Holotype Male, Nevada, Nye Co., Nevada Test Site, Study ECB (foothills west of Yucca Flat), August 11, 1961.

Allotype Female, Nevada, Nye Co., Nevada Test Site, Study 1BD11 (Yucca Flat), October 13, 1960. Both specimens are deposited in the U. S. National Museum.

This species belongs to the subgenus *Geotettix*, *Fusiformis* series, of Hubbell, but its relationship within that series is questionable. In his monograph Hubbell emphasized the importance of the setose/non-setose nature of the ventral carinae of the tarsi. These setae, though present in nymphal instars, may be completely absent in adult specimens, the setae apparently decreasing in number with succeeding instars. The *Fusiformis* group, principally of the northern Great Plains area but extending as far west as northern Utah (*C. fusiformis* Scudder) is typified by having the tarsal segments setose. The *Caudelli* group, on the other hand, more western in distribution, has non-setose tarsal segments. The present species is setose and would belong to the *Fusiformis* group. According to the characters given in Hubbell's keys to species, *deserticola* is more closely related to *fusiformis*.

Description of Holotype Male. Body length 15.7 mm. Dorsum, including abdomen, moderately polished, subglabrous, notal setae minute and scattered, abdominal setae much more numerous and evenly spaced. HEAD. Eyes small in size, length 0.7 mm., breadth 0.5 mm.; interocular distance 1.3 mm., infraocular distance 1.4 mm., clypeal suture 1.7 mm.; antennae very long, approximately three times body length; distal segment of maxillary palpus 1.8 mm.; fastigium as in *fusiformis*, strongly declivent, flattened above, apex in side view slightly more prominent than margins of antennal fossae, bluntly rounded-obtuse, with erect setae. THORAX. Length of pronotum 3.5 mm., greatest breadth 4.1 mm., depth (in side view) 2.1 mm., in dorsal aspect subquadrate, cephalic margin slightly emaginate, caudal margin truncate, ventrolateral margins rather strongly arcuate, moderately projected outward, broadest point just caudad of midlength; mesonotal length 2.3 mm., greatest breadth 4.3 mm., caudal margin, in dorsal aspect, broadly convex; metanotal length 1.55 mm., greatest breadth 4.0 mm., caudal margin in dorsal aspect truncate. LEGS. Cephalic femur (Figure 127), length 4.5 mm., breadth 1.0 mm., slightly stouter than middle femur, ventrocephalic carina with 4-4 spurs, the distal spur 0.55 mm. long, twice as long as other spurs; middle coxa with dorsocephalic carina explanate distad, distal angle weakly produced and forming a small projection; middle femur, ventrocephalic carina with 4-3 spurs, ventrocaudal with 4-5 spurs. Caudal femur (Figure 128) short, stout, length 9.8 mm., greatest breadth 3.1 mm., tapering distad to base of genicular lobes, ventrocephalic carina with 45 closely set, somewhat irregularly spaced subequal spinulose denticulations, ventrocaudal carina with 57 similar but somewhat smaller denticulations, these appearing mesially in two series on either side of carina, dorsal denticulations about 48, scattered on distal half of femur, both caudal and cephalic genicular lobes distinctly spinulose. Caudal tibia straight, 11.2 mm. in length, dorsal spurs (Figure 129) moderately slender and elongate, subdistal spur of cephalic carina 1.1 mm. long, spurs gently curved, apex minutely hooked, dorsal face bicarinate, outer face sparsely setose, the setae varying on different spurs, spines of carinae averaging 8 between spurs, approximately equal in number between spurs; subdistal ventral spurs 1-1; dorsocephalic calcar 0.95 mm. in length, the other calcars being 1.7 mm. and 1.05 mm., respectively. Metatarsus 2.0 mm. long, 2nd segment of tarsus 0.6 mm. long, 0.5 mm. wide, 4th segment 1.3 mm. long, claws 0.8 mm. long, metatarsus with a row of stout setae on ventral carina.

Terminal Abdominal Structures (Figures 121, 123-126). Dorsocaudal margins of abdominal tergites 1 to 6 truncate, of 7th weakly rounded-angulate, of 8th rather strongly produced, the caudal edge slightly convex upward, 9th tergite strongly exposed and thickened caudad, broadly emarginate, in lateral view 9th tergite strongly convex upward, completely concealing phallic complex and equidistant caudad to subgenital plate. Epiproct membranous, its distal portion compressed between dorsal margins of paraprocts, margins slightly elevated, straight and convergent to arcuate-emarginate apex. Supra-anal plate seemingly absent, bent beneath epiproct. Epiphallus narrow, sides of rami divergent, rami narrow, separated by rather broad quadrate opening occupied by membrane; dorsum of arch bearing widely separated and well chitinized paired auriculae curved along dorsal margin of epiphallus, cephalic lobe short, dorsal curvature of epiphallus as a narrow, recurved flange. Subgenital plate weakly sclerotized, suborbicular in ventrocaudal aspect, broadest proximally, apices rounded, together forming rounded termination with narrow mesal cleft, the terminal portion less sclerotized, separated from basal portion by distinct sulcations angulate from the mesal cleft.

Description of Allotype Female. General characteristics as given for male holotype. Body length 21.2 mm., ovipositor length 6.2 mm. HEAD. Eyes, length 0.7 mm., breadth 0.6 mm., interocular distance 1.3 mm., infraocular distance 1.35 mm., clypeal suture 1.7 mm., distal segment of maxillary palpus 1.9 mm. THORAX. Pronotal length 3.5 mm., greatest breadth 4.4 mm., depth, in side view, 2.3 mm.; mesonotal length 2.15 mm., greatest breadth 4.8 mm. in dorsal aspect; metanotal length 1.7 mm., greatest breadth 4.7 mm. LEGS. Cephalic femur, length 4.6 mm., breadth 1.0 mm., ventrocephalic carina with 3-3 spurs, the distal spur 0.5 mm. long; middle femur, ventrocephalic carina with 3-4 spurs, ventrocaudal carina with 4-4 spurs. Caudal femur length 9.8 mm., greatest breadth 3.1 mm., ventrocephalic carina with 41 spinulose denticulations, ventrocaudal carina with 56 denticulations, dorsal denticulations 41, both caudal and cephalic genicular lobes distinctly spinulose. Caudal tibia 10.0 mm. in length, subdistal spur of cephalic carina 1.1 mm. long, spines of carinae averaging 8 between spurs; subdistal ventral spurs 1-1; dorsocephalic calcar 0.95 mm. in length, the other calcars being 1.75 mm., 1.0 mm., and 0.55 mm., respectively; metatarsus 2.3 mm. long, 2nd segment of tarsus 0.7 mm. long, 0.6 mm. wide, 4th segment 1.3 mm. long, claws 1.1 mm. long, metatarsus with a row of stout setae on ventral carina, proximal one-half of 2nd tarsal segment with setae.

Terminal Abdominal Structures. Cerci slender, 4.0 mm. long; subgenital plate simple. Ovipositor (Figure 122) 6.2 mm. long, slightly upcurved, dorsal valves terminating in elongate, slenderly aciculate point; distal one-third of ventral valves with five elongate, slenderly aciculate teeth, the distal and subdistal teeth decidedly curved and separated by rounded intervals, the three proximal teeth separated by less rounded intervals.

Coloration. Entire body of both sexes uniformly pale, the only contrast being the eyes, the anterior articulations of the mandibles, the mandibles themselves at the clypeal sutures, and the spinulose denticulations. The tips of the spines, the spurs and the calcars are dark. The auriculae of the epiphallus of the male are darkened and the tips of the acicular teeth and terminal dorsal valves of the female are similarly darkened. The tibiae and tarsi are only slightly darker than the general body coloration.

Variation. The usual variation in size is noted in Table 53 on page 102. In addition, there appears such obvious variants as the spurs of the ventrocephalic carina of the cephalic femur. Occasionally there are only two spurs, frequently three, but generally four. These are noticeably spaced differently, probably due to the loss of a spur during growth of the individual. Where the spur is missing from the carina there is always a space, indicating that it has been broken off. There is even a variation of the spurs on the left and right femora of the same insect. Characteristics of the carinae of the tibiae were not observed as regularly, but the usual variations in these conditions could be expected. The spinulose denticulations of the caudal femora vary within recognized limits, not only as to size but also to number. Conditions of the terminal abdominal appendages of both male and female are remarkably consistent in the observed specimens.

Habitat. This insect has been collected under extreme conditions of aridity, surrounding the playa lakes of both Frenchman and Yucca flats. Owing to the absence of large rocks or other suitable ground cover, it undoubtedly is an inhabitant of rodent burrows which are so common throughout these areas. It is present, also, along the bajadas and into the lower foothills surrounding the mountains. All the specimens were captured in regularly maintained can traps

FIG. 121

FIG. 122

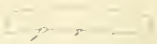


FIG. 127

FIG. 124

FIG. 123

FIG. 125

FIG. 129

FIG. 126

FIG. 128

Figs. 121-129. *Ceuthophilus deserticola*. 121, male paratype, epiphallus. 122, female allotype, distal valves of ovipositor, lateral view. 123, male holotype, apex of abdomen, lateral view. 124, male holotype, subgenital plate, caudal view. 125, male holotype, epiproct. 126, male holotype, distal abdominal tergites, dorsal view. 127, male holotype, cephalic margin of cephalic femur, lateral view. 128, male holotype, caudal femur, lateral view. 129, male holotype, caudal tarsus, lateral view.

Table 53. Size variation of *Ceuthophilus deserticola*.

	Length Eye	Breadth Eye	Interocular Distance	Length Maxillary Palpus	Length Pronotum	Length Cephalic Femur	Length Caudal Femur	Breadth Caudal Femur	Length Caudal Tibia	Length Metatarsus	Length 2d Tarsal Segment	Breadth 2d Tarsal Segment	Length 4th Tarsal Segment	Length Tarsal Claws	Length Ovipositor
♂, Holotype	0.7	0.5	1.3	1.8	3.5	4.5	9.8	3.1	10.4	2.0	0.6	0.5	1.3	0.8	
♂, Paratype, Minimum	0.65	0.4	1.1	1.7	3.2	4.3	9.0	2.75	9.8	2.0	0.6	0.5	1.2	0.8	
♂, Paratype, Average	0.728	0.496	1.283	1.846	3.417	4.742	9.95	1.988	10.492	2.108	0.675	0.508	1.317	0.967	
♂, Paratype, Maximum	0.8	0.5	1.4	2.1	3.8	6.2	11.0	3.2	11.4	2.4	0.8	0.55	1.4	1.1	
♀, Allotype	0.7	0.6	1.3	1.9	3.5	4.6	9.8	3.1	10.0	2.3	0.7	0.6	1.3	1.1	6.2
♀, Paratype, Minimum	0.65	0.45	1.1	1.5	3.1	3.9	8.3	2.45	8.7	1.8	0.6	0.5	1.2	0.9	5.1
♀, Paratype, Average	0.737	0.53	1.267	1.81	3.467	4.553	9.58	2.897	10.12	2.08	0.66	0.547	1.327	1.106	6.167
♀, Paratype, Maximum	0.9	0.6	1.5	2.1	4.1	5.3	11.6	3.3	12.0	2.3	0.7	0.6	1.5	1.2	7.1

with the exception of the holotype male which was captured from one of the lower foothills in the vicinity of Yucca Flat. The area is composed of coarse sand from the weathered granitic rocks, and the one specimen was captured by the author from underneath one of the large rocks on the west slope of a hill, while specifically looking for fossorial Orthoptera. The concealment of the insect by the sand was remarkable.

Seasonal Occurrence. Late instar nymphs have been collected only in June, July and August. This does not correlate with the appearance of subadults and adults, however, and it is likely that the early instars cannot be distinguished from those of *C. fossor*. Subadults were collected in April, May, and June. Adults have been taken during all months of the year except January. The wide overlap in appearance of this insect is undoubtedly due to the environment in which it is found, the winters being sufficiently mild that the insect can make periodic appearances during the winter months. See Table 54 for the appearance of these insects.

Distribution. The present known distribution of this insect is limited to the Nevada Test Site, Nye County, Nevada. Insufficient collecting has been done in surrounding areas to arrive at any definite conclusions as to its total distribution. It should be found through the more arid regions of the Great Basin, undoubtedly extending into southeastern California.

Localities Represented. Specimens examined (nymphs, subadults, and adults): 55, as follows: 7 male nymphs, 5 female nymphs, 4 subadult females, 20 adult males, 19 adult females.

Salsola (studies 1F, 5HQ), 6 specimens, June 16 to December 4.

Grayia-Lycium (studies 1B, 1G, 4A), 34 specimens, February 2 to December 5.

Atriplex-Kochia (study 6A), 5 specimens, July 17 to October 13.

Coleogyne (study 10D), 2 specimens, March 3 and June 12.

Mixed (studies ECA, NCB), 5 specimens, August 21 to November 27.

Study EM, 1 specimen, August 11.

Study 5HL, 2 specimens, October 30 and November 3.

Ceuthophilus hebardi Hubbell

(Figures 91, 97-99, 130-137; Table 55; Map 26)

1936. *Ceuthophilus hebardi* Hubbell, U. Florida Biological Series, Vol. II, No. 1, pp. 457-460.

Distinctive Features. Superficially, all the *Ceuthophilus* species at the Nevada Test Site resemble each other. They can best be told by the conditions of the terminal abdominal appendages. These differences can be recognized by the illustrations and the key to the species. At the test site, *hebardi* most resembles *deserticola*, but the differences are obvious as illustrated by the figures.

Coloration. At the Nevada Test Site the species is somewhat darker than species found at lower elevations. There is a correlation with environment in this respect. The soil on Rainier Mesa is considerably darker than the soil around the playa lakes. The specimens are quite uniformly colored, any infuscations and barring are indistinct.

Distribution. The type locality of this species is at a high elevation (10,000 feet) in Iron County, Utah. It is known only from western Utah and southern Nevada, not necessarily at high elevations because of specimens taken at St. George, Washington Co., Utah (Hubbell, 1936).

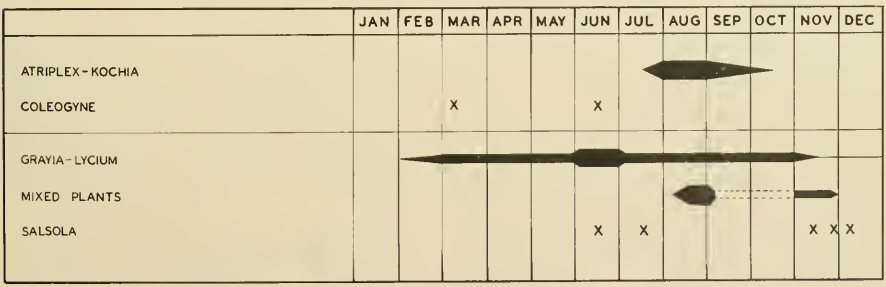
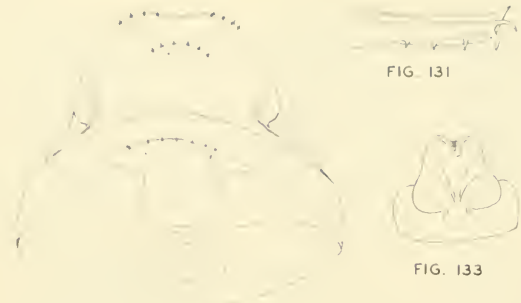
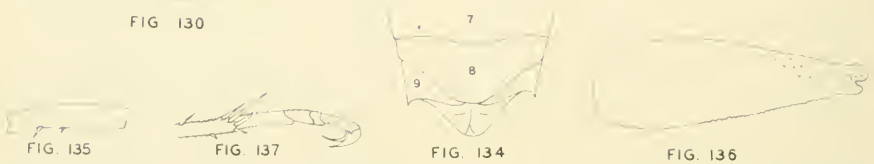


Table 54. Seasonal distribution of *Ceuthophilus deserticola*.





Figs. 130-137. *Ceuthophilus hebardi*. 130, male, epiphallus. 131, female, distal valves of ovipositor, lateral view. 132, male, apex of abdomen, lateral view. 133, male, subgenital plate, caudal view. 134, male, distal abdominal tergites, dorsal view. 135, male, cephalic margin of cephalic femur, lateral view. 136, male, caudal femur, lateral view. 137, male, caudal tarus, lateral view.

Table 55. Size variation of *Ceuthophilus hebardi*.

	Length Eye	Breadth Eye	Interocular Distance	Length Maxillary Palpus	Length Pronotum	Length Cephalic Femur	Length Caudal Femur	Length Caudal Tibia	Length Metatarsus	Length 2d Tarsal Segment	Breadth 2d Tarsal Segment	Length 4th Tarsal Segment	Length Tarsal Claws	Length Ovipositor
♂, Minimum size, 12AC9, July 25, 1961	0.6	0.5	1.0	1.5	2.7	3.1	7.2	7.6	1.3	0.6	0.55	1.0	0.6	
♂, Average	0.661	0.516	1.106	1.578	2.922	3.533	7.789	8.156	1.422	0.689	0.483	1.094	0.628	
♂, Maximum size, 12EC3, July 25, 1961	0.7	0.55	1.15	1.8	3.2	4.2	9.3	9.5	1.8	0.8	0.5	1.3	0.7	
♀, Minimum size, 12AC1, October 27, 1961	0.65	0.5	1.0	1.45	2.85	3.3	7.2	7.5	1.4	0.6	0.4	0.95	0.6	4.2
♀, Average	0.7	0.571	1.107	1.65	3.236	3.9	8.243	8.343	1.493	0.693	0.479	1.114	0.729	4.971
♀, Maximum size, 12EC2, August 24, 1961	0.8	0.65	1.2	1.9	3.9	6.0	10.3	10.5	2.3	0.8	0.55	1.5	1.1	6.4

At the Nevada Test Site it was found only in two studies on Rainier Mesa.

Habitats. Nothing is known of the habitats of this species, inasmuch as the specimens were captured in can traps established in the studies. It can be suggested, however, that the species lives under rocks or in other holes in the ground. Of the total series, 72.2% were taken in the disturbed area, where it was found with *C. nevadensis* and *Pristoceuthophilus pacificus*, apparently living in the fissures and under the loosened rocks caused by the nuclear explosion.

Seasonal Occurrence. Three male adults were collected on April 10. The area was not visited until July, when both nymphs and adults were found. Both nymphs and adults were present until October 28. They were most numerous during the month of August. This species is apparently most active during summer and early autumn.

Localities Represented. Specimens examined (nymphs and adults): 115.

Study 12A, 83 specimens, April 10 to October 28.

Study 12E, 32 specimens, April 10 to October 28.

Additional Remarks. In his description of the species, Hubbell described only the male, and gave measurements only on that sex. Measurements and drawings of the females of this species are here given for the first time.

Ceuthophilus fossor Hubbell

(Figures 82, 83, 89, 90, 138-147; Tables 56, 57; Map 27)

1936. *Ceuthophilus fossor* Hubbell, U. Florida Biological Series, Vol. II, No. 1, pp. 484-488.

Distinctive Features. This species can best be recognized by the row of numerous nodules or denticulations on the ventrocephalic carina of the cephalic femur. These denticulations are even present on the nymphs, although they are less conspicuous. The males can definitely be distinguished by the two finger-like lobes of the subgenital plate. These lobes are present on the male nymphs, more distinguishable, of course, with later instars.

Morphological Variation. As with any large series of orthopterans, there is considerable variation in the structures of this insect. A more noticeable variation is the nature of the subdistal spurs of the cephalic femur. The usual condition is with one spur. A very few specimens have two spines, and one female has one spine on one cephalic femur, two on the other. These differences have no appearance as being the result of an injury where the spines might have been broken off.

Coloration. This species is very nearly uniform light colored, with the tendency to darkened tibiae in the subadults of both sexes. This darkened character is carried over in some adults. The genicular area of the caudal femora and the caudal tibiae are generally darkened.

C. fossor can be distinguished from *C. lamellipes*, the other very common gryllacridid at the Nevada Test Site, by the light maculations on that species. The nymphs of *lamellipes* are very maculate, while the nymphs of *fossor* are nearly unicolorous.

Distribution. The type locality of this species is near Tucson, Pima Co., Arizona. It ranges over the desert regions of Arizona, Nevada and California. At the Nevada Test Site it was collected in all studies where can traps were maintained, except at high elevations.

Habitats. The distribution of this species points to the fact that it is an inhabitant of rodent burrows, primarily. Like the other gryllacridids it is nocturnal and omnivorous.

Seasonal Occurrence. Nymphs and adults have been collected throughout the year in all months. It is primarily a spring insect, the adults being most common from April to June. Adults were present in very few numbers from August to February. Nymphs began to appear more abundantly in October and declined in June. See Table 57 for the occurence and distribution of the species.

Localities Represented. Specimens examined (nymphs and adults): 1,415.

Salsola area (Study 1F), 245 specimens, November to July.

Grayia-Lycium area (studies 1B, 1G, 4A), 872 specimens, collected in all months.

Larrea-Franseria area (studies 5A, 5CQ), 16 specimens, April 3 to November 7 (no specimens collected in July, August, or October).

Table 56. Size variation of *Ceuthophilus fossor*.

	Length Eye	Breadth Eye	Interocular Distance	Length Maxillary Palpus	Length Pronotum	Length Cephalic Femur	Length Caudal Femur	Length Caudal Tibia	Length Metatarsus	Length 2d Tarsal Segment	Breadth 2d Tarsal Segment	Length 4th Tarsal Segment	Length Tarsal Claws	Length Ovipositor
♂, Minimum size, 1FA3, June 19, 1961	0.8	0.65	1.3	1.7	3.5	4.2	9.3	9.5	1.7	0.5	0.6	1.3	0.9	
♂, Average	1.006	0.75	1.713	1.893	4.138	5.15	11.25	11.713	1.913	0.594	0.713	1.469	1.043	
♂, Maximum size, 4AL4, May 10, 1961	1.25	0.9	2.5	2.15	5.1	6.2	13.7	14.4	2.2	0.7	0.9	1.7	1.2	
♀, Minimum size, 1FL2, June 19, 1961	0.8	0.6	1.4	1.7	3.8	4.5	10.0	10.0	1.7	0.5	0.65	1.3	0.9	4.7
♀, Average	0.92	0.705	1.44	1.775	4.0	4.64	10.36	10.41	1.74	0.555	0.63	1.34	0.965	5.07
♀, Maximum size, 1BD25, May 23, 1961	1.0	0.75	1.7	2.2	4.6	5.6	12.0	11.7	1.9	0.6	0.8	1.4	1.1	5.7

FIG. 138

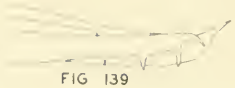


FIG. 139

FIG. 140

FIG. 142

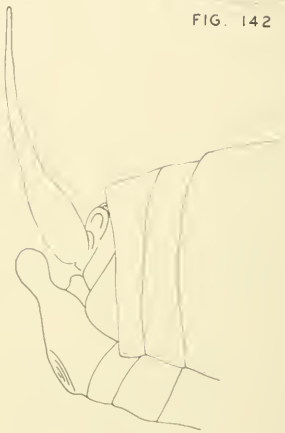


FIG. 141

FIG. 143

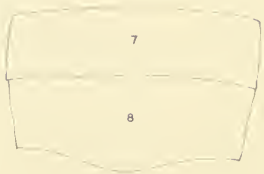


FIG. 144

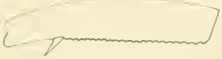


FIG. 145

FIG. 147

FIG. 146

Figs. 138-147. *Ceuthophilus fossor*. 138, male, epiphallus. 139, female, distal valves of ovipositor, lateral view. 140, female, distal valves of ovipositor, lateral view. 141, male, apex of abdomen, lateral view. 142, male, subgenital plate, caudal view. 143, male, epiproct. 144, male, distal abdominal tergites, dorsal view. 145, male, cephalic margin of cephalic femur, lateral view. 146, male, caudal femur, lateral view. 147, male, caudal tarsus, lateral view.

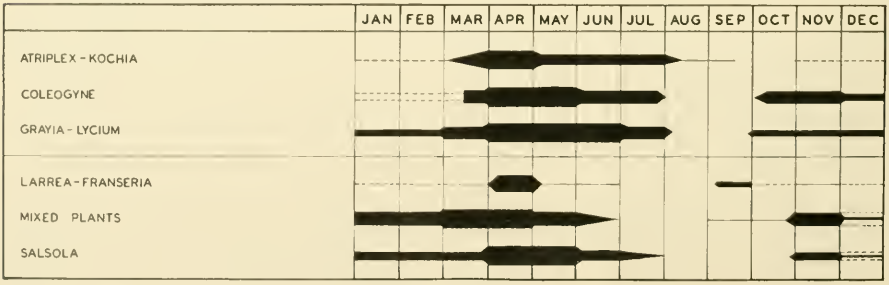


Table 57. Seasonal distribution of *Ceuthophilus fossor*.

Atriplex-Kochia area (Study 6A), 29 specimens, February 23 to September 18.

Coleogyne area (Study 10D), 73 specimens, October to July (no specimens collected in January or February).

Artemisia area (Study TA), 2 specimens, April 15 and June 20 .

Lycium area(Study 5E), 33 specimens, November 28 to June (no specimens collected in December or January).

Mixed areas (studies CBA, JA, 12CJ), 134 specimens, September to June.

Study 10S, 11 specimens, January 19 and June and July.

Ceuthophilus lamellipes Rehn

(Figures 87, 92, 93, 148-154; Tables 58, 59; Map 28)

1907. *Ceuthophilus lamellipes* Rehn, Proc. Acad. Nat. Sci. Philadelphia, LIX, pp. 78-80, figs. 19, 20.

Distinctive Features. This species can be distinguished from the other ceuthophili found at the Nevada Test Site by the very large tooth (ventrocephalic carina strongly lamellate-explanate) of the caudal femur of the male, the smaller tooth of the female, and by the numerous small denticulations on the dorsal and cephalic surface of the caudal femur in both sexes, more numerous and stronger in the male. It can also be told by the purplish markings (especially in the nymphs and subadults) on the caudal femur and the dorsum of the thorax and abdomen. The terminal abdominal structures of the male, of course, are the most reliable criteria.

The female nymphs have a slight indentation on the caudal femur, the male nymphs more noticeably dentate.

Morphological Variation. The comments under "Morphological Variation" of *C. fossor* can also be applied to this species. A considerable degree of variation was found with respect to the appendages, especially their spines and denticulations.

Coloration. Color markings of this species have previously been discussed. This is the most maculate member of the genus *Ceuthophilus* on the test site, resembling *Pristoceuthophilus*, found only at higher elevations, in that respect. These two insects may be confused by superficial study, but are quite different morphologically.

Distribution. The type locality of this species is Phoenix, Maricopa Co., Arizona. It has previously been reported only from Arizona and northwestern Utah in Tooele County. Its distribution is shown now to extend into western Nevada, and it should be found in eastern California. At the Nevada Test Site it was found in all areas except at higher altitudes. It is undoubtedly limited to a desert environment.

Habitats. The species is found in rodent burrows, under rocks and debris, and, although not proven, undoubtedly burrows in the loose sand according to the rugose nature of the appendages.

Seasonal Occurrence. In contrast to the earlier occurrence of *C. fossor*, this species appears later in the season. Nymphs were collected in all months of the year, although they were

Table 58. Size variation of *Ceuthophilus lamellipes*.

	Length Eye	Breadth Eye	Interocular Distance	Length Maxillary Palpus	Length Pronotum	Length Cephalic Femur	Length Caudal Femur	Length Caudal Tibia	Length Metatarsus	Length 2d Tarsal Segment	Breadth 2d Tarsal Segment	Length 4th Tarsal Segment	Length Tarsal Claws	Length Ovipositor
♂, Minimum size, 1BB30, February 1, 1961	0.95	0.75	1.3	2.1	3.5	4.6	10.5	[1]	1.8	0.7	0.5	1.3	0.7	
♂, Average	1.04	0.86	1.44	2.35	4.11	5.31	12.06		2.0	0.785	0.59	1.405	0.88	
♂, Maximum size, 6AL11, October 13, 1960	1.15	1.0	1.5	2.6	4.8	6.1	13.6		2.2	0.9	0.65	1.5	1.0	
♀, Minimum size, 1BB5, February 9, 1961	0.95	0.8	1.1	2.0	3.7	4.1	9.1	9.5	1.6	0.6	0.5	1.1	0.7	4.4
♀, Average	1.015	0.83	1.2	2.115	3.8	4.47	9.78	10.08	1.76	0.69	0.545	1.2	0.79	4.62
♀, Maximum size, 1FL2, November 13, 1961	1.1	0.9	1.3	2.35	4.4	5.0	11.2	11.3	1.9	0.95	0.6	1.3	0.9	5.0

[1]Measurements of the length of the caudal tibia of the males were not made because of the normal curvature of that structure (See Figure 154).

FIG. 148

FIG. 149

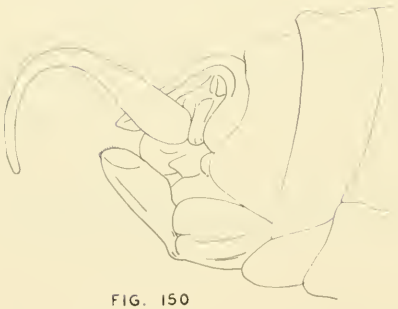


FIG. 150

FIG. 152

FIG. 151

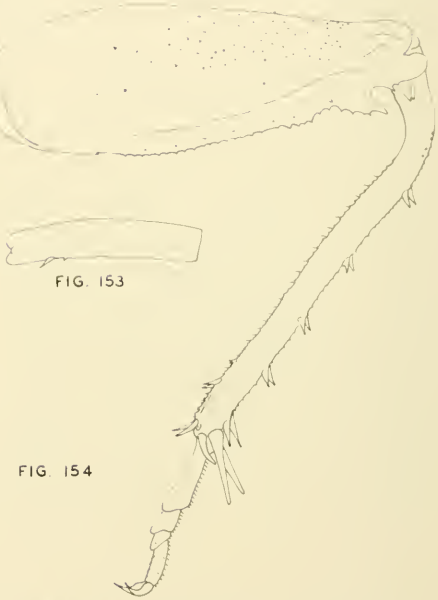


FIG. 153

FIG. 154

Figs. 148-154. *C. lamellipes*. 148, male, epiphallus. 149, female, distal valves of ovipositor, lateral view. 150, male, apex of abdomen, lateral view. 151, male, subgenital plate, caudal view. 152, male, distal abdominal tergites, dorsal view. 153, male, cephalic margin of cephalic femur, lateral view. 154, male, caudal appendage, lateral view.

not abundant from November to May. The adults made their first appearance in August and were present from then into May. They were most numerous from October to March. (See Table 59 for occurrence.)

Localities Represented. Specimens examined (nymphs and adults): 2,344.

Salsola area (Study 1F), 223 specimens, from July to April (no specimens collected in May or June).

Grayia-Lycium area (studies 1B, 1G, 4A), 1,167 specimens, collected throughout the entire year, in all months.

Larrea-Franseria area (studies 5A, 5CQ), 67 specimens, from July to May (no specimens collected in June).

Atriplex-Kochia area (Study 6A), 188 specimens, collected throughout the year, in all months except January.

Colcogyne area (Study 10D), 258 specimens, from July to May (no specimens collected in June).

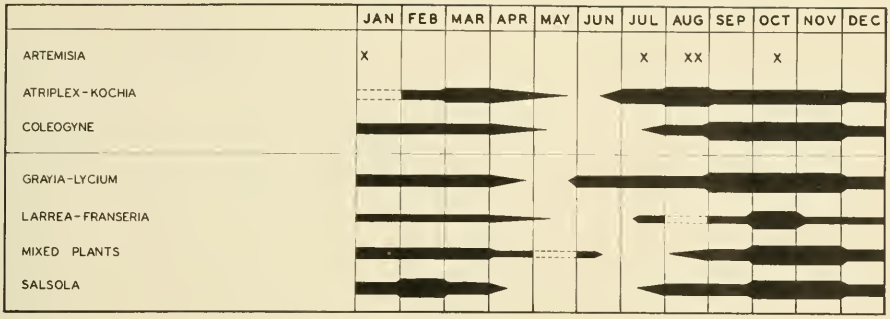


Table 59. Seasonal distribution of *Ceuthophilus lamellipes*.

Eriogonum area (Study 5HL), 24 specimens, October 1 to November 8.

Lycium area (Study 5E), 147 specimens, from July to May (no specimens collected in June).

Mixed areas (studies 6FL, CBA, JA), 217 specimens, collected throughout the year, in all months except May and July.

Artemisia area (Study TA), 6 specimens, January 8 (2 specimens) and July 19 to October 11.

Study 10S, 47 specimens, June 19 to July 11. (These studies were not maintained for an entire year, and the occurrence of the species does not correlate with the known occurrence for the test site.

Genus *Pristoceuthophilus* Rehn

1902. *Pristoceuthophilus* Rehn, Trans. Amer. Entom. Soc., XXIX, p. 17.

Pristoceuthophilus pacificus (Thomas)

(Figures 84-86, 155-160; Table 60; Map 29)

1872. *Ceuthophilus pacifica* Thomas, Rep. Geol. Surv. Territ. Montana, p. 436.

Distinctive Features. This species, even in the early nymphal stages, can be easily distinguished from *Ceuthophilus*, although the superficial resemblance is striking, especially to *C. lamellipes*. The adults are smaller than any known species of *Ceuthophilus* at the Nevada Test Site. More striking differences, however, are presented by the conical development of the vertex of the head, especially pronounced in the nymphs, in the possession of only three pairs of spurs on the posterior tibiae, in the non-spinous median coxae, and the very long first hind tarsal segment, much longer than the remaining portion. The anterior femora are without spines, the middle femora smooth except for the spine on the external carina, the posterior femora are bullate, suggestive of *C. lamellipes*. The tibiae bear many small spines between the larger ones.

Additional criteria are the styles of the male and the broadly emarginate subgenital plate. The ventral ovipositor valves of the female are armed distad with crenulations or numerous low serrations rather than the acicular teeth of the preceding genus.

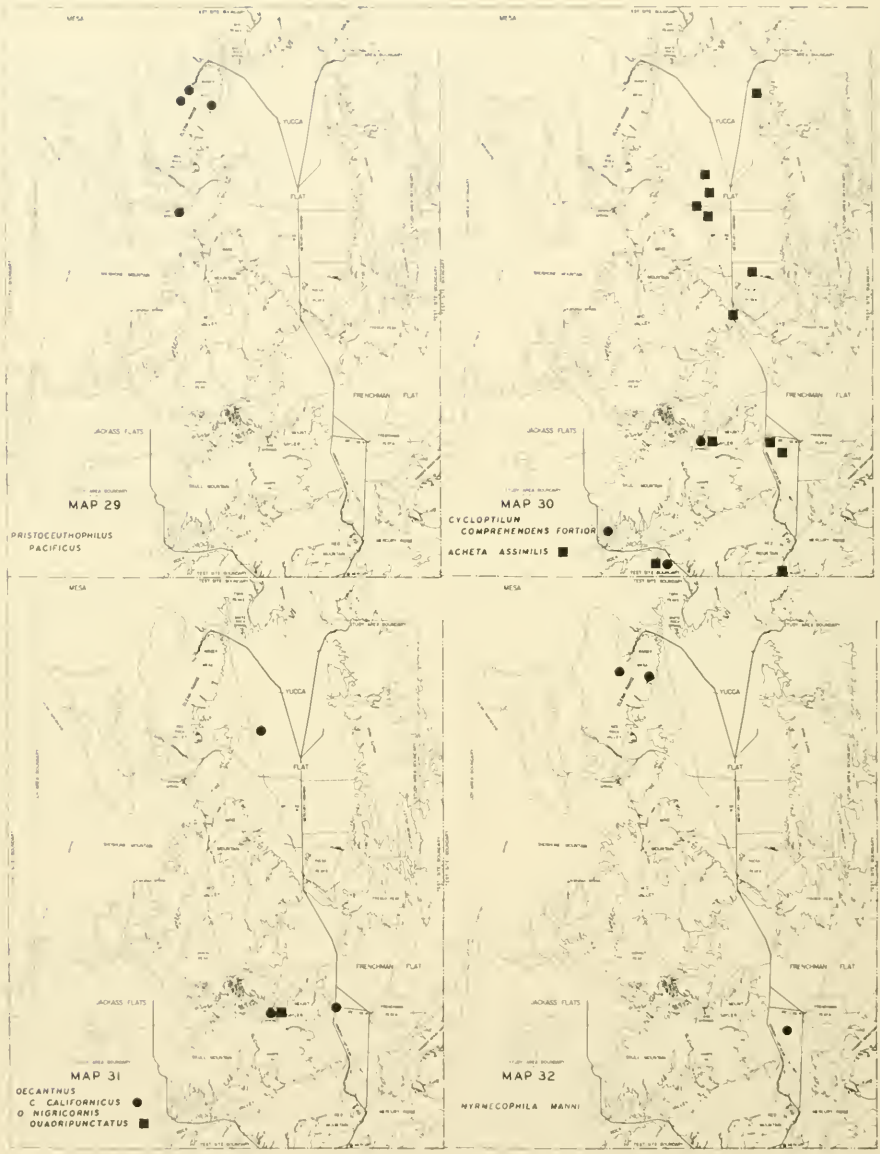
The dorsal surface of the abdomen of the adult male is covered by small tubercles on all the segments and they are generally distributed over these segments.

The nymphs, even early instars, can be told from the species of *Ceuthophilus* by the exceedingly bullate clypeus, which is less noticeable in the adult. Otherwise they are similar to the nymphs of *C. lamellipes*.

Coloration. This species most nearly resembles *Ceuthophilus lamellipes* in color and markings. The nymphs are very suggestive of that species. The adults, however, are much more maculate than the adults of *lamellipes*. The ground color of the species is opaque yellowish brown with the numerous brownish-purple maculations.

Distribution. The species has been recorded from various places throughout California and from Nevada. At the Nevada Test Site it was collected only at higher elevations, especially on Rainier Mesa.

Habitats. This species is very common in the disturbed area (Study 12A) of Rainier Mesa,


MESA
YUCCA
FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 29
PRISTOCEUTHOPHILUS PACIFICUS
MAP 30
CYCLOPTILUM COMPREHENDENS FORTIOR
ACHETA ASSIMILIS
MAP 31
OECANTHUS
C CALIFORNICUS
O NIGRICORNIS
QUADRIPUNCTATUS
MAP 32
MYRMECOPHILA MANNI

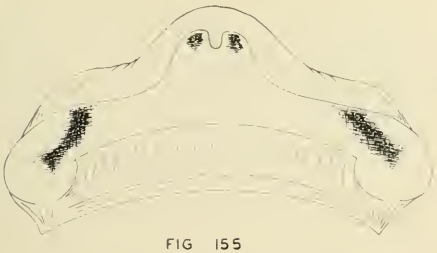


FIG 155

FIG 156

FIG. 159

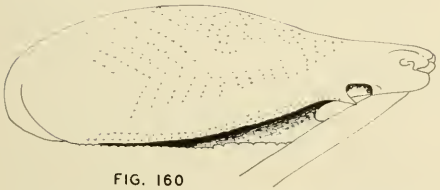


FIG. 160

FIG. 158

FIG. 157

Figs. 155-160. *Pristoceuthopilus pacificus*. 155, male, epiphallus. 156, female, distal valves of ovipositor, lateral view. 157, male, apex of abdomen, lateral view. 158, male, subgenital plate, caudal view. 159, male, distal abdominal tergites, dorsal view. 160, male, caudal femur, lateral view.

Table 60. Size variation of *Pristoceuthophilus pacificus*.

	Length Eye	Breadth Eye	Interocular Distance	Length Maxillary Palpus	Length Pronotum	Length Cephalic Femur	Length Caudal Femur	Breadth Caudal Femur	Length Caudal Tibia	Length Metatarsus	Length 2d Tarsal Segment	Breadth 2d Tarsal Segment	Length 4th Tarsal Segment	Length Tarsal Claws	Length Ovipositor
♂, Minimum size, 12AC5, Oct. 1, 1961[19]	0.6	0.6	0.8	1.7	2.5	3.6	8.0	2.7	[20]	1.6	0.7	0.5	0.8	0.5	
♂, Average[21]	0.66	0.62	1.0	1.98	3.088	4.013	9.113	3.425		1.85	0.825	0.519	0.938	0.5	
♂, Maximum size 12EC8, Oct. 27, 1961	0.7	0.7	1.2	2.1	3.6	4.7	10.0	4.2		2.1	0.9	0.6	1.0	0.5	
♂, Minimum size, TCM, Dec. 4, 1961[22]	0.6	0.5	0.9	1.6	2.3	2.9	7.2	2.3	7.0	1.3	0.6	0.4	0.7	0.4	3.7
♀, Average	0.65	0.563	0.95	1.825	2.78	3.46	7.78	2.46	7.86	1.6	0.688	0.45	0.75	0.45	4.74
♀, Maximum size, 12AC9, Oct. 23, 1961	0.7	0.6	1.0	2.0	3.1	3.7	8.5	2.5	8.9	1.9	0.8	0.5	0.8	0.5	5.7

where numerous fissures occur and where the rocks have been loosened. The insects were most commonly found in can traps, although some were found under rocks and collected by hand. It was established that the species lives under rocks, and undoubtedly lives in the ground fissures in the area. They were uncommon in the undisturbed area (Study 12E), and were not found under the rocks in that area with any regularity.

[19]This specimen is a young adult. Old male specimens can be recognized by the curved tibiae There is apparently a slight increase in size, which would indicate one ecdysis in the adult stage.
[20]Measurements of the male caudal tibia were not made because of the curvature of that structure.
[21]Averages include measurements on three young adults.
[22]This specimen is a young female adult, although it showed no signs of being teneral.

Seasonal Occurrence. The complete seasonal occurrence can not be given for this species inasmuch as the studies in which it is found were not operated continuously as they were at lower elevations. Nymphs were collected from July 18 to November 2. Adults were collected from August 11 to January 10. The nymphs were most common in August, the adults most common in October.

Localities Represented. Specimens examined (nymphs and adults): 196.

Study ECH, 1 adult male, January 10.

Study TCM, 1 adult female, December 4.

Studies 12A and 12E, 194 nymphs and adults as follows: 70 nymph males, 81 nymph females, 12 adults males, 31 adult females, from July 18 (nymphs) to November 9 (adult male).

Additional Remarks. There is some question as to whether or not this series represents a different species, or whether or not subspeciation might have taken place. No comparisons were made.

Family GRYLLIDAE

The crickets have long, delicately tapered antennae and, except for *Myrmecophila,* auditory organs on the front tibiae. The males have stridulatory organs on the tegmina, except, again, for *Myrmecophila* which is completely wingless. Crickets differ from the other Ensifera, the long-horned grasshoppers, in having three-segmented tarsi, an awl-like or needle-like ovipositor, and, when winged, tegmina which are flat above and bent sharply downward at the sides of the body. They are essentially nocturnal, but are also active to a considerable extent during the day. Some are among the commonest insects and are widely distributed; others are rare and very local in distribution.

Crickets are more omnivorous than long-horned grasshoppers and will eat animal substances and other insects. The tree-crickets, particularly, feed largely upon aphids.

In life history, crickets agree, with few exceptions, with the majority of the Orthoptera in hatching from the egg early in the season and developing to maturity during the summer. The eggs of field crickets are deposited in the soil; those of tree-crickets are placed in the bark or pithy stems of the plants among which they live, in holes drilled by the female.

Key to the Subfamilies of GRYLLIDAE

1. Caudal tibiae armed with rows of long spines (Fig. 100) 2

   Caudal tibiae without rows of long spines, but with rows of short teeth (Fig. 101); body covered with scales. ..... Subfamily Mogoplistinae, page 113

2. Completely wingless; hind femora ovate, enormously enlarged (Fig. 102); eyes small; size minute, less than 4 mm. in total body length. Inhabitants of ants nests. ..... Subfamily Myrmecophilinae, page 116

   Winged, at least in the adult male; hind femora elongate; eyes not small; size well over 4 mm., medium to large insects 3

3. Caudal tibia with minute teeth between the spines (figs. 103, 104); head horizontal; form slender. Greenish. ..... Subfamily OEcanthinae, page 115

   Caudal tibia lacking minute teeth between the spines; head vertical; form robust. Brown or black. ..... Subfamily Gryllinae, page 113

FIG. 100

FIG. 101

FIG. 102

FIG. 103

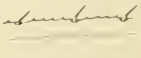


FIG. 104

Figs. 100-104. 100, *Acheta assimilis,* female, caudal tibia and tarsus, lateral view. 101, *Cycloptilum, comprehendens fortior,* male, caudal tibia and tarsus, lateral view. 102, *Myrmecophila manni,* male, caudal appendage, lateral view. 103, *OEcanthus californicus californicus,* male, caudal appendage, lateral view. 104, *OE. c. californicus,* male, detail of caudal tibia, lateral view.

Subfamily Mogoplistinae

The bush-crickets are small (approximately 10 mm. in total body length), flat, slender-bodied insects, brown in color and covered by translucent scales. The hind tibiae have two rows of short teeth but no true spines, which character will distinguish them from all other species in this family.

Genus *Cycloptilum* Scudder

1869. *Cycloptilum* Scudder, Proc. Boston Soc. Nat. Hist., XII, p. 142.

Cycloptilum comprehendens fortior Hebard

(Figure 101; Table 61; Map 30)

1931. *Cycloptilum comprehendens fortior* Hebard, Trans. Amer. Entom. Soc., LVII, pp. 153-157.

Distinctive Features. This thamnophilous cricket is distinctive and will not be confused with any other insect from the Nevada Test Site. It is characterized by the body covering of translucent scales and the absence of spines on the caudal tibiae.

Coloration. The head and pronotum of this insect are reddish brown, the short wings of the male are light brown, the dorsal abdomen of the female dark brown to blackish.

Distribution. The type locality of this species was designated as Ajo, Pima Co., Arizona. The species, itself, extends from the Great Plains states south to Texas and west to California. The race *fortior* is the southwestern representative, being found from western Texas to southeastern California and south into Mexico. At the Nevada Test Site is was found in only three areas, near Cane Springs and Jackass approach.

Habitats. This cricket inhabits the desert regions and is present over most of the Lower Sonoran zone throughout its range. The insect is nocturnal, and was collected only in the can traps established in the studies. It apparently moves at night but is secretive during the day. The song is reported as a high-pitched trilling which is continued over a considerable period.

Seasonal Occurrence. Specimens were collected only in September and the insect can be found at the test site probably in late summer and early fall.

Localities Represented. Specimens examined (adults): 4.

Study CBA, 1 adult male, 2 adult females, September 2 and 14.

Study JA, 1 adult female, September 2.

Additional Remarks. This insect is probably more common than would be indicated by the citations. Some areas were swept for the insect, however, without success. It should be searched for in the evenings when it first becomes active.

The specimens were compared with *Cycloptilum comprehendens interior* Hebard from the type locality in Washington County, Utah, and they are distinctly of the *fortior* group. No variation or intergradation could be detected by the few specimens.

Subfamily Gryllinae

This subfamily includes the common crickets which need no introduction to anyone aware of the insect world. They are robust, brown or black, and easily recognized morphologically by the rows of fixed spines on the caudal tibiae.

Table 61. Size variation of *Cycloptilum comprehendens fortior*.

	Length Body	Length Pronotum	Length Exposed Tegmen	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♂, CBA1, September 2, 1959	7.2	2.8	2.3	4.0	1.5	
♀, CBA2, September 14, 1961	7.7[23]	1.8	0.0	4.0	1.5	3.4
♀, CBA8, September 2, 1961	[24]	1.7	0.0	4.3	1.5	3.65
♀, JAL8, September 2, 1961	7.9	1.9	0.0	4.2	1.5	3.5

[23]The length of the body does not include the ovipositor.
[24]The head is missing from the specimen.

Genus *Acheta* Fabricius

1775. *Acheta* Fabricius, Systema Entomologiae, Flensburgi et Lipsiae, p. 279.

Acheta assimilis Fabricius

(Figures 77, 78, 116; Table 62; Map 30)

1775. *Acheta assimilis* Fabricius, Syst. Ent., p. 280.

Synonomy. The synonomy of this species is still in question. More than 45 names have been applied to the American field crickets. Rehn and Hebard (1915) concluded that only one highly variable species was represented, and since that time all of the native field crickets have been discussed under the name of *assimilis*. This common insect has been discussed in literature under the generic names of *Gryllus* and *Gryllulus*.

Alexander (1957) recognizes five species of field crickets in eastern United States in addition to the house cricket, *Acheta domesticus* (Linnaeus). Even though the type locality of *assimilis* is in Jamaica, the western populations of the field cricket are recognized as that species until a complete revision is made of the American field crickets.

Distinctive Features. This is the very common thick-bodied cricket which is so widely distributed. No other insect at the Nevada Test Site even resembles the species. There are certain dark crickets, smaller in size, throughout the west (genus *Nemobius*) which resemble *assimilis*, but which can be recognized by the large movable spines of the caudal tibiae. In *Acheta* the spines are not movable.

Morphological Variation. Probably no other species of Orthoptera has as much variation as this insect. Extreme differences can be found in a series collected at the same time in one area, in the development of the wings and tegmina, the distribution of hairs on the body, and even the development of the appendages.

Coloration. The color of the field cricket ranges from light brown through dark brown and almost black. There is considerable color variation in the series from the test site. Specimens from higher elevations tend to be darker and smaller; specimens from more sandy areas tend to be larger and much lighter. Intermediate forms can also be found. They are all generally quite unicolorous.

Distribution. In North America the field cricket can be found nearly everywhere except at high altitudes and in the far north. It apparently cannot tolerate too much moisture as it is not found in wet areas. It is found nearly everywhere over the Nevada Test Site, but was not collected on Rainier Mesa.

Habitats. Most of the insects were captured in can traps where they were collected as a result of their nocturnal wanderings. They seek refuge during the day under any debris or under rocks on the ground. They are particularly active after a summer's rain. The nymphs are more active during dry periods. In July, 1961, the adults were taken in the can traps only after a rain, although the nymphs were previously collected from the same areas.

Seasonal Occurrence. Nymphs were collected throughout the entire year, except no specimens were taken during February and December, and only one in January. Adults were collected from April through September. They were most common during the month of May.

Localities Represented. Specimens examined (nymphs and adults): 113.

Salsola area (Study 1F), 6 specimens, July 5 to November 24.

Grayia-Lycium area (studies 1B, 1G, 4A), 59 specimens, January 17 to October 24.

Larrea-Franseria area (Study 5A), 1 specimen, October 16.

Atriplex-Kochia area (Study 6A), 4 specimens, May 3 to September 6.

Table 62. Size variation of *Acheta assimilis*.

	Length Body[25]	Length Pronotum	Length Tegmen	Extension of Wing Beyond Tegmen	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♂, Minimum Size	24.6	2.9	8.8	0.0	9.7	3.2	
♂, Maximum Size	31.7	3.5	12.6	10.8	11.4	4.0	
♀, Minimum Size	27.3	3.7	10.9	9.3	9.6	2.8	12.2
♀, Maximum Size	34.7	4.6	14.9	10.7	11.6	3.7	14.2
♀, CBA5, July 1, 1960	34.5	3.9	8.0	0.0	13.0	4.6	14.3

[25]Length of body includes ovipositor or cerci according to sex.

Coleogyne area (Study 10D), 1 specimen, July 5.

Lycium area (Study 5E), 2 specimens, July 18 and August 13.

Yucca-Coleogyne area (Area 6), 10 specimens, August 28.

Mixed areas (studies CBA, JA), 27 specimens, May 16 to November 24.

Area 6, miscellaneous collection, 1 specimen, August 22.

Study CM, 1 specimen, March 14.

Study MD, 1 specimen, September 1.

Subfamily OEcanthinae

The tree crickets are small, delicate creatures, whitish in color, usually shaded with green or brown. The wings are fully developed in both sexes, in the male the tegmina broadly expanded and paddle-shaped, flat on the back, in the female the tegmina narrow and wrapped closely about the body. The ovipositor of the female is rod-shaped.

Tree crickets are found on trees and shrubs, or on vegetation generally, only accidentally on the ground. Their songs are loud and are among the most noticeable night noises. These insects are most active at night, but may be encountered during the day. They feed not only on leaves, flowers, fungi, and fruit, but consume large numbers of small insects, such as aphids and scales.

The eggs are deposited in the bark of trees or in the pithy center of plants, in holes made by the ovipositor of the female. During their early nymphal existence they possess pronounced predaceous habits. As they approach maturity they become more vegetarian.

Genus *OEcanthus* Audinet-Serville

1831. *OEcanthus* Audinet-Serville, Ann. Sci. Nat., XXII, p. 134.

OEcanthus californicus californicus Saussure

(Figures 103-105; Map 31)

1874. *OEcanthus californicus* Saussure, Miss. Scient. Mex., Rech. Zool. VI, p. 462.

Distinctive Features. The tree-crickets are distinctive insects and can be recognized by the characters given in the keys. There is no other insect found at the Nevada Test Site with which they can be confused. The two species found in the fauna at the test site can be distinguished by color and markings on the antennal segments.

Coloration. This insect is ivory to quite brownish, with a reddish tinge, especially on the head. The first and second antennal segments are plain, unmarked, or marked with a single narrow dark line.

Distribution. It is limited to the western United States where it is widespread. At the Nevada Test Site it was very limited in distribution and probably never appears commonly.

Habitats. This tree-cricket is most commonly found on the larger shrubs and, in certain areas, in trees. The only recorded vegetation from the Nevada Test Site was from *Atriplex canescens*.

Seasonal Occurrence. The incidence of the insect at the test site is unknown. It was collected only in August and September, and throughout most of its range is a late summer and early fall insect.

Localities Represented. Specimens examined (nymphs and adults): 4.

Area 4, miscellaneous collection, 1 adult male, August 26, no record of the vegetation upon which it was taken.

FIG. 105

FIG. 106

Figs. 105-106. 105, *OEcanthus californicus californicus*, male, proximal antennal segments, cephalic view. 106, *OE. nigricornis quadripunctatus*, male, proximal antennal segments, cephalic view.

Key to the Species of *OEcanthus*

Front side of first antennal segment never ornamented with more than a narrow black line along inner edge (Fig. 105); subgenital plate of female with a notch half as broad as the widest part of the plate; tegmina of male plainly colored. *OE. californicus californicus* Saussure

Front side of first two antennal segments ornamented with two black marks, the first segment with black line and dot which are narrow and well separated (Fig. 106); female subgenital plate with a narrow notch ..... *OE. nigricornis quadripunctatus* Beutenmuller

Area 5, miscellaneous collection, 1 adult male, September 26, no record of the vegetation.

Area CM, Cane Springs, 2 female nymphs, August 10 and 22, on *Atriplex canescens*.

OEcanthus nigricornis quadripunctatus Beutenmuller

(Figure 106; Table 63; Map 31)

1894. *OEcanthus quadripunctatus* Beutenmuller, Bull. Amer. Mus. Nat. Hist., VI, p. 271.

Distinctive Features. The features by which this tree-cricket can be distinguished from *californicus* are the markings on the antennae. The first and second antennal segments each have two black marks on the under (front) side, the inner mark on the first segment is linear, straight, the distal end with a tendency to curve outward toward the outer spot which is small and round.

Coloration. Compared to the other tree-cricket from the test site, *quadripunctatus* is pale greenish-white, becoming yellowish when dried.

Distribution. This insect has a wide distribution over the United States from Canada to Texas and from the Great Plains westward. It was found only at Cane Springs at the Nevada Test Site.

Habitats. Low, heavy vegetation is the usual habitat of this group. At the Nevada Test Site it was collected on *Elymus cinereus*.

Seasonal Occurrence. The specimens were collected in June, but no information can be given as to its seasonal occurrence at the test site. It is, however, an earlier insect than *californicus*.

Localities Represented. Specimens examined (nymphs and adults): 3.

Study CM, Cane Springs, 3 specimens, 1 male subadult, 1 female subadult, 1 female adult, June 15 and 24, on *Elymus cinereus*.

Additional Remarks. It is rather difficult to determine with any certainty a race of Orthoptera on the basis of just one adult specimen, especially where color markings are key factors. The one female, however, has more the typical antennal markings of *quadripunctatus* to the east (through Utah and Colorado), and is less distinctive of the heavier markings of *O. nigricornis argentinus* Saussure of the Pacific States. The group may actually show an intergrading at the Nevada Test Site, or even be more typically *argentinus*, if a large series could be obtained.

Subfamily MYRMECOPHILINAE

Genus *Myrmecophila* Latreille

1829. *Myrmecophila* Latreille, Regne Anim., (ed. 2), V, p. 183.

The ant-loving crickets can be recognized by their extremely small size and the fact that, with few exceptions, they are found as commensals of ants. (Specimens have been found by the author under rocks where no ants could be located. Colonies of ants may have, at one time, been located under the rocks, but none were there when the crickets were captured.) The various species of crickets can be determined by the number and proportionate length of the spines and spurs of the caudal tibia, and the spines and spinulae of the caudal metatarsus. The dorsal margins of the caudal tibia are armed with one external and three or four internal spines; the distal extremity is armed with three pairs of spurs, the ventral pair being minute.

Myrmecophila manni Schimmer

(Figure 102; Table 64; Map 32)

1911. *Myrmecophila manni* Schimmer, Deutsch. Ent. Seitschr., 1911, p. 443.

Distinctive Features. This species can be recognized by the characters discussed under the genus above. Specifically, the dorso-internal margin of the caudal tibiae are armed with four spines, alternating in length. In his revision of the genus, Hebard (1920b) commented that rarely in *manni* one spine is missing.

Coloration. The general coloration of the species is pale, yellowish brown or slightly darker, except the eyes which are blackish-brown and the distal portion of the female ovipositor which is shining dark reddish-brown. The abdominal segments are sometimes margined

Table 63. Measurements of *OEcanthus nigricornis quadripunctatus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Breadth Caudal Femur	Length Ovipositor
♀, CM, June 24, 1961	18.2	2.0	11.7	8.0	0.9	4.6

Table 64. Size variation of *Myrmecophila manni.*

	Length Body	Breadth Body	Length Pronotum	Breadth Pronotum	Length Caudal Femur	Breadth Caudal Femur	Length Caudal Tibia	Length Tarsi	Length Metatarsus	Length External Tibial Spine	Length Cereus	Length Cephalic Femur	Length Ovipositor
♂, 12E, July 24, 1961	3.4	1.78	0.88	1.65	1.6	0.95	1.18	1.3	0.85	0.5	1.2	0.88	
♂, 12A, July 24 ,1961	4.0	2.1	0.93	1.85	1.88	0.98	1.4	1.3	0.9	0.63	1.43	0.9	
♀, 12AC9, August 12, 1961	3.53	2.1	1.15	2.03	1.98	1.03	1.43	1.35	1.03	0.65	1.45	0.98	1.3
♀, 12AC9, August 14, 1961	4.25	2.28	1.08	2.08	1.93	1.05	1.45	1.4	1.0	0.5	1.53	0.9	1.4

caudad with a slightly darker shade, giving these individuals a banded appearance. All of the immature specimens are noticeably light tan in color.

Distribution. This species is typically an inhabitant of the semi-arid and arid regions of the western United States, ranging from southern Washington to the Mexican border. The insect was collected at the Nevada Test Site in two extreme areas: one immature specimen was collected at the edge of the playa at Frenchman Flat; the other habitat, one where *Myrmecophila* was common, was at a higher elevation in the pinyon-juniper areas on Rainier Mesa.

Habitats. This species is a commensal of ants, the host species at the Nevada Test Site being *Formica integroides planipilis* Creighton, *Formica fusca* Linnaeus, *Formica lasioides* Emery, and *Camponotus vicinus* Mayr. (Determinations of ants were made by Dr. Arthur C. Cole, who has been associated with the radiation ecology project at Mercury.) The one nymph from Study 5E was captured in a can trap. In a subsequent visit to this station a colony of *Pogonomyrmex californicus* (Buckley) was found within a few feet of the trap, and although the tunnels and nest were carefully exposed no other specimens were collected. One significant generalization can be made from the capture: the crickets do leave the protective custody of the ant colonies and wander about on the ground, probably being nocturnal.

On Rainier Mesa some of the specimens were captured with ants in can traps established in the area, but more frequently they were captured by turning over rocks, under which ant colonies would be found. In these situations the crickets were always, without exception, clinging to the rocks rather than being on the ground. This habit was observed by the author in many collections in widely separated areas in Washington and Kane counties, Utah. Whenever the crickets and ants were found under any moveable object, stone or board, the crickets would be clinging to the object removed. This has also been the habit of *Mrymecophila oregonensis* Bruner collected by the author in Oregon.

In an effort to determine the habits of this species of cricket the author maintained a colony of ants, crickets and other mrymecophilous arthropods in the laboratory and a number of significant observations were made. These specimens were not from the Nevada Test Site, but from the vicinity of St. George, Utah, and while the artificial conditions may be different and the crickets react differently under laboratory conditions, the information may contribute to a general knowledge of the group. The first observations were made from October 28 to November 25. The material was originally collected from the ant's nest, including soil, grass and roots, and different arthropods including ants and their eggs, pseudoscorpions, small tenebrionid beetles, hister beetles, collembola, and fifteen crickets in various stages of development. They were introduced into a glass jar for observations.

The adult crickets almost immediately seemed to establish territories and would not approach other adults. They would extend their legs to maximum extensions (standing up) in order to see over a larger area and ward off any intruder. This territorialism may account for the fact that very few specimens are found in any one colony of ants, at least in those areas examined.

The following day cracked wheat and grass seeds were introduced to the colony and the crickets fed upon this material, or at least they were attracted by it.

During the first week of observation the crickets spent most of their time on the exposed grass roots and stems and had not apparently invaded the ant chambers which had been dug. They were extremely active over the surface area at night, only moderately active by day. Some of the ants had died off during the first

week, but the collembola, especially, were adjusted to the laboratory conditions in that their numbers had increased.

After this colony had been maintained for two weeks nearly all the ants had died off. Additional ants, along with dirt and debris, were collected from the same natural colony and re-established in the laboratory. Three crickets were also introduced with this second addition.

On November 11 both the crickets and the collembola had multiplied, as there were many first instar nymph crickets among the grass. No cricket eggs had been observed, but they may have been present in one or both of the introductions.

The crickets were seldom seen in the ant burrows by day or night, but apparently preferred the grass.

This original experiment was terminated because the plant materials molded and all the insect life eventually died off.

Another colony was established in February in a special narrow chamber, glassed on both sides, so any digging and activity underground could be noted. Ants and crickets were placed in the chamber and after the establishment of tunnels some table sugar was placed on the surface. Some of the crickets went directly to the sugar and began eating it, but avoided the ants.

It was observed that the crickets stood up as high as possible very frequently and in so doing the females would thrust the ovipositor forward to be cleaned by the mouthparts. The hind tarsi and tibiae were also cleaned in this same manner. The crickets always avoided the ants and never came close enough to them to feed on the oily secretions on the surface of the body of the ants, as stated by Wheeler (1900). Observations made by various authors indicate that the food of these crickets is largely the secretions which lubricate the ants' bodies and which are left on the walls of their passage-ways, this being partly the food of the ants, also. This could not be contradicted nor substantiated in the observations made. Hebard (1920b) stated that *Myrmecophila* are wholly dependent upon the host for the type of nourishment required. It was found, however, in all colonies examined that whenever protection was offered, as in the case of a rock or board over the ant nest, the crickets emerged from the nest and found shelter under the cover and away from the ants. They retreated for the protective custody of the ant nest when molested, but would not enter until they could do so without running into the ants.

In the special chamber where the underground activity could be observed, whenever a cricket would emerge into a tunnel, it would immediately jump and remain on the ceiling whenever an ant would come through the tunnel, returning to the bottom after the ant had gone.

Myrmecophilus seems to breed at any season inasmuch as nymphs have been found throughout the year.

Seasonal Occurrence. No complete seasonal data can be given for this species because of the few trips and records made from Rainier Mesa, the area where the insects were found. Nymphs and adults were collected only during the months of July and August, with most of the captures of both nymphs and adults being in July.

Localities Represented. Specimens examined (nymphs and adults): 11.

Study 5EA7, Frenchman Flat, 1 male nymph, July 15, commensal of *Pogonomyrmex californicus* (?).

Study 12A, disturbed area on Rainier Mesa, 7 nymphs and adults as follows: 3 nymph males, July 24 to August 24, commensal with *Formica integroides planipilis* (2 specimens) and *Formica lasioides* (1 specimen); 1 adult male and 3 adult females, July 24 to August 14, commensal with *Formica fusca* (1 specimen) and *Formica integroides planipilis* (3 specimens).

Study 12E, undisturbed area on Rainier Mesa, 3 nymphs and adults as follows: 1 nymph, sex not determined, and 1 female nymph, July 24, commensal with *Formica fusca*; 1 adult male, July 24, commensal with *Componotus vicinus*.

Additional Remarks. It is interesting to note that the comparative numbers of specimens is the same as the species of *Ceuthophilus* and *Pristoceuthophilus*, in that most of the specimens have been collected from the disturbed area on Rainier Mesa where the rocks have been loosened and fissures occur in the ground.

Although the genus *Myrmecophila* was revised in 1920, additional work is needed to redefine the various species and to designate their distributions.

Suborder PHASMATOPTERA
Superfamily PHASMATOIDEA
Family PHASMATIDAE

The walking-stick is among the curiosities of the insect world. It has an elongate, slender, and cylindrical body with an exserted head. The prothorax is very short, the meso- and meta-

Key to the Subfamilies of Phasmatidae

Antennae not more than one-half as long as the anterior femora ..... Subfamily Pachymorphinae, page 119

Antennae distinctly longer than the anterior femora ..... Subfamily Heteronomiinae, page 119

thorax elongate. The legs are slender and all alike in form. Tegmina and wings are lacking in all of the United States species. A large arolium is present between the claws at the end of the five-segmented tarsus. The ovipositor of the female is concealed by the subgenital plate and the cerci are not segmented.

The walking-sticks are remarkable for their resemblance to twigs of plants or to dead grass. They are protected effectively by their habit of moving very slowly and deliberately and of remaining motionless for long periods of time, which makes them very difficult to observe. The legs, if lost, may under certain circumstances, be regenerated, and individuals exhibiting appendages in this process are not infrequently seen. These regenerated appendages may be distinguished by the absence of one tarsal segment.

The eggs closely resemble seeds of plants and are dropped on the ground at random. All of the walking-sticks feed on the leaves of plants. They are herbivorous and are usually found on shrubs and trees or among grasses.

The insects can best be collected by sweeping the vegetation inasmuch as they are difficult to see before capture.

Subfamily Pachymorphinae

Genus *Parabacillus* Caudell

1903. *Parabacillus* Caudell, Entom. News, XIV, p. 314.

Parabacillus hesperus Hebard

(Map 33)

1934. *Parabacillus hesperus* Hebard, Trans. Amer. Entom. Soc., XL, pp. 286-290.

Distinctive Features. This is a medium or small and extremely slender walking-stick. The antennae are short, less than three times the length of the head. The surface is smooth, without tubercles, but with a prominent medio- longitudinal carina on the pronotum and with coarse low sub-marginal longitudinal carinae on each side. The limbs are very slender, unarmed. The female is considerably longer and more robust than the male.

Coloration. The coloration is typically straw-yellow, but may vary from light to dark brown. A striking broad band of brown is present on the head and thorax but becomes weak on the abdomen.

Distribution. The range of this species is from Oregon and California east to Utah and Arizona. At the Nevada Test Site it was found only in Area 6.

Habitats. This species is largely found on range grasses, but has been reported from rabbit brush, burroweed and other desert perennials. It was found in a *Yucca-Colcogyne* area at the Nevada Test Site, but no record of the vegetation was made upon which the insect was found.

Seasonal Occurrence. The only collection of the insect at the test site was in August. No other data can be given as to its seasonal occurrence.

Localities Represented. Specimens examined (adult): 1.

Area 6, miscellaneous collection, 1 specimen, August 28.

Subfamily Heteronemiinae

Genus *Pseudosermyle* Caudell

1903. *Pseudosermyle* Caudell, Proc. U.S. Nat. Mus., XXVI, p. 867.

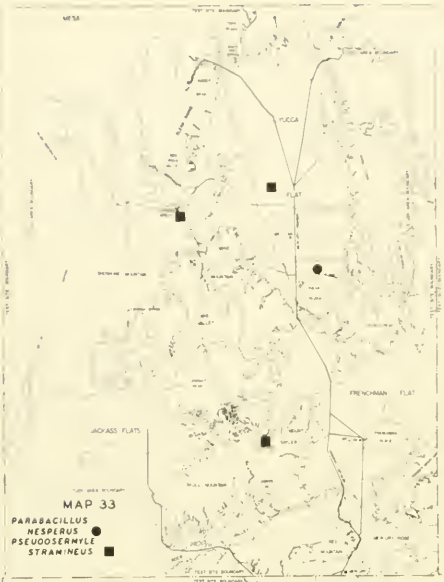
Pseudosermyle strameneus (Scudder)

(Table 65; Map 33)

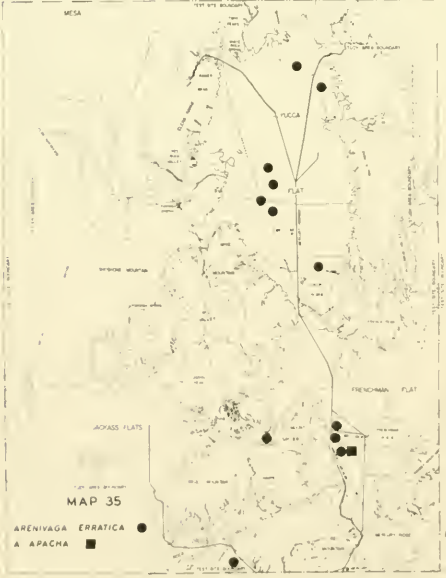
1902. *Bacunculus strameneus* Scudder, Proc. Davenport Acad. Sci., IX, p. 20.

Established Synonomy. *Pseudosermyle truncata* Caudell; *Pseudosermyle tenuis* Rehn and Hebard.

Distinctive Features. This species can be distinguished from the other walking-stick found on the Nevada Test Site by the longer antennae, distinctly longer than the anterior femora in both sexes. The surface is sub-rugose and the head has two pairs of prominent carinae. The males differ from the females in being entirely smooth except for two main carinae on the anterior part of the head between the eyes, and in being smaller and more slender.


MESA
YUCCA FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 33
PARABACILLUS HESPERUS
PSEUDOSERMYLE STRAMINEUS

MESA
YUCCA FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 34
LITANEUTRIA MINOR
STAGMOMANTIS CALIFORNICUS


MESA
YUCCA FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 35
ARENIVAGA ERRATICA
A APACHA

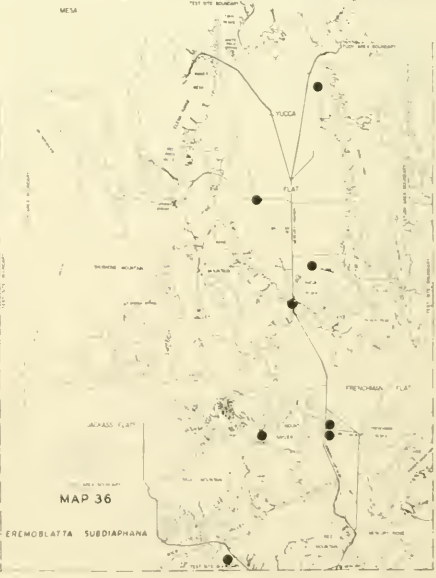

MESA
YUCCA FLAT
FRENCHMAN FLAT
JACKASS FLATS
MAP 36
EREMOBLATTA SUBDIAPHANA

Table 65. Size variation of *Pseudosermyle strameus*.

	Length Body	Length Pronotum	Length Mesonotum	Length Metanotum	Breadth Pronotum	Length Cephalic Femur	Length Middle Femur	Length Caudal Femur	Length Antennae
♂, 1GD1, July 17, 1961	40.5	1.8	9.8	6.8	1.2	14.1	12.2	15.7	27.0
♂, TCB, June 22, 1961	33.7	1.7	7.5	6.3	0.8	12.2	10.0	13.1	24.5
♀, CM, June 13, 1961	37.8	2.1	8.4	6.4	1.6	9.5	7.4	9.1	12.2

Coloration. The color of this species, more striking than *Parabacillus*, is usually gray, but may be pink or yellowish. Occasional specimens are greenish or whitish. The carinae give the specimens a more maculate appearance.

Distribution. This species has a considerable altitudinal range from southern California east to Colorado, New Mexico and Texas. At the Nevada Test Site it was found at Cane Springs, near Midvalley, and on Yucca Flat.

Habitats. This walking-stick is occasionally found feeding on grass, but more often is found on shrubs and perennial plants. It is generally quite common when found, but only three specimens were collected at the test site.

Seasonal Occurrence. Complete data are unavailable on the occurrence of the species. It was collected as adults from June 13 to July 17.

Localities Represented. Specimens examined (adults): 3.

Study 1GD1, 1 male, July 17.

Study CM, 1 female, June 13.

Study TCB, 1 male, June 22.

Suborder Dictyoptera

Superfamily Mantodea

Family Manteidae

The praying mantids are strikingly peculiar in appearance. The body is elongate with a free and transverse head and a vertical face. The cephalic appendages are raptorial with free, elongate coxae; the femora and tibiae are enlarged and spined for seizing insect prey. The middle and caudal appendages are slender. The tegmina and wings are often shorter than the abdomen in the females. The abdomen of the female is often much broader than that of the male and is without a visible ovipositor. Both sexes have a pair of short jointed cerci attached to the sides of the epiproct, while the males also have a pair of much shorter styles near the apex of the subgenital plate. Sound producing organs are absent.

The Manteidae differ from all other Orthoptera in being exclusively carnivorous upon living insects. They are esteemed as highly useful and beneficial. A praying mantid often takes two grasshoppers at a time, grabbing one in each appendage. It eats the prey alive, usually starting at the base of the head. The females are cannibalistic and often devour their mates after copulation.

The eggs are laid in conspicuous ootheca attached to twigs of trees or stems of grasses. The winter is spent in the egg stage, the young hatch in the spring and seek plant lice and other soft-bodied insects for their first food.

Subfamily Amelinae

Genus *Litaneutria* Saussure

1892. *Litaneutria* Saussure, Soc. Ent. VII, p. 123.

Key to the Superfamilies of Dictyoptera

Anterior legs highly specialized for grasping prey; body very elongate and narrow ..... Superfamily Mantodea, page 121

Anterior legs not specialized for grasping; body ovate or subovate .. Superfamily Blattodea, page 124

Key to the Subfamilies of Manteidae

Size small, less than 32 mm. long; pronotum subequal in length to anterior coxa; posterior femora armed with an apical spine ..... Subfamily Amelinae, page 121

Size large, more than 50 mm. long; pronotum much longer than anterior coxa; posterior femora with no apical spine ..... Subfamily Manteinae, page 122

Litaneutria minor (Scudder)
(Table 66; Map 34)

1872. *Stagmatoptera minor* Scudder, U. S. Geol. Surv. Nebraska, Final Report, Part 3, p. 251.

Established Synonomy. *Litaneutria ocularis* Saussure; *Litaneutria obscura* Scudder; *Litaneutria pacifica* Scudder; *Litaneutria skinneri* Rehn; *Litaneutria longipennis* Beier.

Distinctive Features. This campestrian species is very distinct from the other mantis found at the Nevada Test Site. It can be distinguished by its much smaller size, by the coloration, and by its habits. The males are usually fully winged, although brachypterous males are found; the wings of the female are usually about one-third the length of the abdomen.

Coloration. The ground color of this insect is usually gray, but may vary from light buff to dark brown. The darker maculations of the body tend to blend well with the environment. Most of the males have a characteristic large black spot in the center of the hind wing.

Distribution. This is a very widespread species of the west, occurring from the Great Plains westward and from British Columbia south into Mexico. It is distributed throughout most of the Nevada Test Site, but was not found at higher elevations.

Habitats. This small, elongated insect can be detected running rapidly about on the ground in the desert areas and will only occasionally resort to vegetation in an effort to escape capture. The terrestrial habits of the insect resulted in its frequent capture in can traps.

Seasonal Occurrence. Collections were made from April 29 to October 30. Nymphs were present into September; adults were first collected in June. It would appear from the occurrence of the nymphs that part of the eggs laid during the summer hatch into nymphs that same season.

Localities Represented. Specimens examined(nymphs and adults): 88.

Salsola area (Study 1F), 2 specimens, June 19 to 23.

Grayia-Lycium area (studies 1B, 1G, 4A) 15 specimens, May 5 to October 30.

Larrea-Franseria area (studies 5A, 5CQ), 9 specimens, April 29 to August 31.

Atriplex-Kochia area (Study 6A), 4 specimens, June 28 to July 14.

Coleogyne area (Study 10D), 20 specimens, June 21 to October 27.

Lycium area (Study 5E), 6 specimens, June 22 to July 27.

Yucca-Coleogyne area (Study 6), 3 specimens, August 28.

Mixed vegetation areas (studies CBA, JA), 19 specimens, May 23 to September 17.

Study CM, Cane Springs, 1 specimen, August 11.

Study 10S, 3 specimens, June 25 to July 3.

Area 5, miscellaneous collecting, 2 specimens, September 26 and October 3.

Area 6, miscellaneous collecting, 1 specimen, July 15.

Camp Mercury area, 3 specimens, August 24.

Additional Remarks. One nymph (5CQ23, July 11, 1961), 5 mm. long, has the eyes distinctly pointed above, suggestive of *Yersiniops*. No other nymphs show this condition and no adults of that genus were collected at the Nevada Test Site. The insect referred to is therefore considered an abberant form of *Litaneutria*.

Subfamily MANTEINAE

Genus *Stagmomantis* Saussure

1869. *Stagmomantis* Saussure, Mitth. Schweiz. Ent. Ges. III, pp. 56, 65.

Table 66. Size variation of *Litaneutria minor*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Length Cephalic Femur
♂, MD, June 7, 1961	23.7	4.5	16.3	6.3	4.2
♂, 5M, September 26, 1961	24.7	4.6	17.3	6.2	4.2
♂, 5M, October 3, 1961	25.0	5.5	6.1	7.0	5.3
♂, 5A, August 31, 1959	27.4	5.1	19.2	8.2	5.4
♀, 5A, August 31, 1959	27.8	6.0	6.2	6.6	5.8

Stagmomantis californicus
Rehn and Hebard
(Table 67; Map 34)

1909. *Stagmomantis californicus* Rehn and Hebard, Proc. Acad. Nat. Sci. Phila., LXI, pp. 409-483.

Distinctive Features. This insect can be readily recognized and distinguished from *Litaneutria* by its large size, its coloration, and its thamnophilous habits.

Coloration. The body of this insect is usually green, but occasional yellowish or brown specimens are found. The brown specimens are most frequently with light maculations. The hind wings are usually brown, often marked with ashy blotches, or frequently purple, red, or even orange-yellow. The wings of the specimens collected at the test site were red, but in observed specimens they changed to brown within four hours after death. The first four dorsal abdominal segments of the male are broadly edged with darker brown.

Distribution This species is common throughout the *Larrea-Franseria* deserts of the southwest. It distribution extends from California east to Colorado and Texas. This mantid is not common at the Nevada Test Site even though it was found in a number of different areas.

Habitats. Generally quite common throughout its distribution, this insect is found on shrubs and low vegetation, and is frequently attracted to lights at night. Its most common occurrence at the test site was on *Larrea divaricata*.

Seasonal Occurrence. Nymphs were collected from July 10 to September 30. The only adult occurrence was in September. The adults undoubtedly are found into October, at least, although no specimens were collected.

Localities Represented. Specimens examined (nymphs and adults): 15.

Study 5A, 4 specimens, July 10 to 18, on *Larrea divaricata*.

Studies CBA and JA, 3 specimens, July 15 to September 2, vegetation not recorded from which the specimens were taken.

Study CM, Cane Springs, 3 specimens, July 15 to September 30, no vegetation records.

Study TCB, 2 specimens, July 16, no vegetation records.

Area 6, miscellaneous collecting, 2 specimens, August 28, no vegetation records.

Camp Mercury area, 1 specimen, September 10.

Additional Remarks. Thomas (1875) reported three specimens belonging to the family Manteidae that were collected by members of the Wheeler Survey, one of which was new and was described at that time as follows:

"*Mantis wheelerii*, sp. nov.

"The specimen is dry, and is so badly damaged that it is impossible to determine positively the genus to which it belongs, or to do more than indicate some of its leading specific characters.

"*Female.*—Head flat, transverse, triangular in front. Occiput short, reduced to a transverse ridge. Vertex transverse, directed downward and backward toward the face, with four slight longitudinal depressions. Ocelli distinct and prominent. The face transversely quadrilateral; the upper carinate margin bent upward between the antennae. The antennae wanting. Prothorax about twice the length of the rest of the thorax; the margins minutely serrate, slightly emarginate, scarcely expanding posteriorly near the transverse incision. Anterior femora denticulate on the exterior carina. Abdomen enlarged, fusiform. Middle and posterior legs wanting, and but a remnant of the wings remaining.

"*Color.*—Yellow, probably faded from a pale green. The abdominal segments with a piceous black fascia or ring on the posterior margin of each. The remnants of the wings carneous-red.

"The specimen is too much injured to give any very acurate measurements; but the follow-

Table 67. Measurements of *Stagmomantis californicus*.

	Length Body	Length Pronotum	Length Tegmen	Length Caudal Femur	Length Cephalic Femur
♂, CM, September 30, 1961	45.1	14.8	15.2	12.6	10.9

Key to the Genera of POLYPHAGIDAE

Middle and caudal femora with dorsal genicular spine at apex (Fig. 107) ..... *Arenivaga* Rehn

Middle and caudal femora without dorsal genicular spine at apex ..... *Eremoblatta* Rehn

ing approximations will indicate the size:— Length, 2.2 inches; prothorax, 1.0 inch; anterior femora, 0.5 inch; anterior tibiae, 0.6 inch."

This species was subsequently placed into synonomy with *Stagmomantis carolina* (Johannson), but the color markings are as in S. *californicus*. Either S. *californicus* of Rehn and Hebard is a color variation of S. *carolina* and should be placed into synonomy, or, if it is a good species, it should be relegated to a synonomic position of *Stagmomantis wheeleri* (Thomas), and the latter reestablished as the scientific name of this insect.

Superfamily BLATTODEA
Family POLYPHAGIDAE

The orthopterans with strongly depressed, more or less oval, bodies are readily referred to the superfamily Blattodea. Other distinguishing characteristics separate them from the other Orthoptera. The head is concealed beneath the pronotum, the face is ventral, the mouth posterior, and the antennae long and filiform. The legs are slender, similar, and compressed, with the coxae long and free. When fully developed, the tegmina are parchment-like and overlapping, and the wings membranous, with a large anal area. Both tegmina and wings are often rudimentary or wanting in the female and sometimes in both sexes. The Nevada Test Site females are all apterous.

The sexes may be distinguished without difficulty, although there is no visible ovipositor. The males are characterized, in addition to the conspicuous cerci, by the presence of a pair of styles at the sides of the caudal margin of the last ventral segment of the abdomen.

These insects are commonly known as roaches. They are nocturnal and remain in darkened places during the day. At night they run about seeking food, and attack everything edible.

FIG. 107

Fig. 107. *Arenivaga erratica*, female, caudal femur showing distal spine, lateral view.

The number of generations of these insects per year appears to differ with the species. The native species produce apparently a single brood per year, but those adventive species, commonly found in houses, may produce several broods per year. The eggs are laid enclosed in ootheca, which shows their true relationships to the mantids, which are carried about for several days protruding from the body of the female before being finally dropped, apparently at random.

The native roaches live under or within objects and are commonly found in rodent nests, especially of the rat *Neotoma*. No attempt has been made to include in this discussion those roaches which might have become established as adventives, and which are found only in the residences and buildings.

The males of the native species are long-winged, buff with brown markings, and are often seen because they are attracted to lights in large numbers. The females are round and wingless. Most of the specimens taken at the Nevada Test Site were collected in can traps as a result of their foraging at night.

Genus *Arenivaga* Rehn

1903. *Arenivaga* Rehn, Proc. Acad. Nat. Sci. Phila., 1903, p. 181.

In his revisionary studies of the genus, Hebard (1920c) stated: "So much individual variation occurs in the species of this genus, in the

Key to the Species of *Arenivaga*
(Modified from Hebard)

Right, ventral genital plate of male without projections, the right dorsal genital plate vertically broad, with margins rounded and surface smooth (Fig. 108). Limbs of female more elongate and slender; dorsal surface of abdomen normally maculate ..... *A. erratica* Rehn

Right ventral genital plate of male with projections; right dorsal genital plate large and lobiform, produced inward from its left distal portion in an elongate heavy spike, the internal margin beyond the base of this spike armed with two small teeth (Fig. 109). Limbs of female shorter and stouter; segments of abdomen normally immaculate .... *A. apacha* (Saussure)

FIG. 108 FIG. 109

Figs. 108-109. 108, *Arenivaga erratica*, male, concealed genital structure. 109, *A. apacha*, male, concealed genital structures.

features normally used for specific separation, that we feel it is imperative for the student to examine the concealed genitalia of all males to be recorded. The other features which we consider of some diagnostic value, and the degree of variation known, are discussed under the species."

Arenivaga erratica Rehn

(Figures 107, 108; Table 68; Map 35)

1903. *Homoeogamia* (*Arenivaga*) *erratica* Rehn, Proc. Acad. Nat. Sci. Phila., 1903, p. 187.

Distinctive Features. Several different species of *Arenivaga* are found in the southwestern desert areas. The two species found at the Nevada Test Site are difficult to differentiate, but may be recognized by an examination of the external genital characters of the male. The females are more problematical in their differentiation, as no reliance can be placed on the dorsal markings.

Coloration. The males of the species are light buff in coloration with tegmina and wings of approximately the same color. The females typically have some darker maculations on the dorsal surface. The ground color of the females is usually darker than the males.

Distribution. This species is more numerous and has a wider distribution than the other *Arenivaga* found at the test site. It is western in distribution, being found from California to western Texas and from southern Utah and southern California to Mexico. It has a wide distribution over most of the Nevada Test Site.

Habitats. Like other roaches, the species is nocturnal, the males being attracted to lights at night. They were most commonly collected in the can traps as a result of their nocturnal wanderings. They are frequently found in rodent nests, or in the tunnels associated with the nests. They are especially common in sandy areas.

Seasonal Occurrence. This roach has been collected from April 4 to October 23. Both nymphs and adults were present from April through October. They are most common during the month of August.

Localities Represented. Specimens examined (nymphs and adults): 99.

Salsola area (Study 1F), 1 specimen, August 4.

Grayia-Lycium areas (studies 1B, 1G, 4A), 47 specimens, April 6 to October 12.

Larrea-Franseria areas (studies 5A, 5CQ), 3 specimens, May 22 to September 2.

Atriplex-Kochia area (Study 6A), 4 specimens, June 26 to September 15.

Coleogyne area (Study 10D), 8 specimens, June 2 to September 15.

Lycium area (Study 5E), 8 specimens, May 4 to August 26.

Mixed vegetation areas (studies CBA, JA), 52 specimens, April 4 to October 23.

Study 10S, 13 specimens, June 19 to 29.

Additional Remarks. The concealed genital characters of the entire series of male specimens of *Arenivaga* collected at the Nevada Test Site were checked. In addition, measurements were made on sufficient female adults to show no statistical differences in the population, so the

Table 68. Size variation of *Arenivaga erratica*.

	Length Tegmen	Breadth Tegmen	Length Body	Breadth Body	Length Pronotum	Breadth Pronotum	Length Cephalic Femur	Breadth Cephalic Femur	Length Middle Femur	Breadth Middle Femur	Length Caudal Femur	Breadth Caudal Femur
♂, CBA5, September 25, 1961	14.2	5.0			4.8	3.4	2.4	0.5	3.0	0.7	3.4	0.7
♂, 5EA9, May 26, 1961	14.7	6.0			3.9	5.5	2.3	0.5	3.0	0.7	3.3	0.7
♀, 1BD25, August 4, 1961			11.9	8.1	3.5	6.5	2.5	0.6	3.3	0.95	3.4	1.1
♀, 10DA9, August 26 ,1961			13.3	8.7	3.5	6.8	2.6	0.6	3.3	0.9	3.5	1.1
♀, CBA5, September 25, 1961			15.7	7.5	2.9	6.2	2.5	0.5	3.2	0.8	3.2	1.0

entire series of females is referred to *erratica* on the basis of numbers. As compared to females of *apacha* from California, there is nothing in the collection from this area to indicate the presence of *apacha* females. Some male specimens had the abdomen broken off and were referred to *erratica* only on the basis of numbers of specimens.

A tiny spine is present on the right ventral genital plate of some males. This condition is slightly atypical to comparative specimens to the east, and the Nevada Test Site specimens may be an undescribed group, intermediate between *apacha* and *erratica*, and may indicate that these two species are the same with the presence of subspeciation over their ranges. A complete revision of the genus will have to be made.

Arenivaga apacha (Saussure)
(Figure 109, Table 69; Map 35)

1893. (*Homoeogamia*) *apacha* Saussure, Rev. Suisse Zool., 1, Fasc. 2, p. 296.

Established Synonomy. (*Homoeogamia*) *apacha infuscata* Caudell.

Distinctive Features. This species can be distinguished from *erratica* with any assurance only by the external genital structures of the male, and even these structures are subject to variation throughout its range.

Coloration. Both sexes are so similar to *erratica* that little distinction can be based on coloration. Generally the males are slightly darker, although light individuals are also found, and the females are reddish brown, as are the females of *erratica*. In *apacha*, however, the females have no dorsal maculations.

Distribution. This species occurs over part of the range of *erratica*, in that it is found from southern California, through extreme southern Nevada, into Arizona, and south into Mexico, the type locality being in the state of Chihuahua. Only one specimen from the Nevada Test Site, collected near Frenchman Playa, was assigned to the species.

Habitats. The information given for *erratica* also applies to *apacha*. The latter species, however, is frequently found on sand dunes throughout its range, and can be recognized and collected, particularly at night, by the small mole-like burrows they make immediately under the surface of the ground. The males, too are attracted to lights at night.

Seasonal Occurrence. The only specimen assigned to this species was collected in May. There is no reason to believe, however, that it occurs any earlier than *erratica*.

Localities Represented. Specimens examined (adult): 1.

Study 5E, 1 adult, May 4.

Additional Remarks. This specimen was compared to a series of males from Riverside County, California, and more nearly resembles this species than it does a large series of *erratica* from a number of localities throughout that species range. For further comments see "Additional Remarks" of that species.

Genus *Eremoblatta* Rehn

1903. *Eremoblatta* Rehn, Proc. Acad. Nat. Sci. Phila., 1903, p. 181.

Eremoblatta subdiaphana (Scudder)
(Table 70; Map 36)

1902. *Homoeogamia subdiaphana* Scudder, Proc. Davenport Acad. Sci., IX, p. 19.

Distinctive Features. This species, although superficially resembling *Arenivaga*, is quite distinct morphologically. The body is moderately covered with yellowish hairs, with the middle and caudal femora very hairy, and lacking the distal spine of *Arenivaga*. Seven spines are found at the distal end of the cephalic tibiae. The males are fully winged, the females wingless.

Coloration. This is a light tan colored species, ranging to a medium brown in some specimens.

Table 69. Measurements of *Arenivaga apacha*.

	Length Tegmen	Breadth Tegmen	Length Pronotum	Breadth Pronotum	Length Cephalic Femur	Breadth Cephalic Femur	Length Middle Femur	Breadth Middle Femur	Length Caudal Femur	Breadth Caudal Femur
♂, 5EA7, May 4, 1961	**14.5**	4.7	5.0	3.5	2.4	0.55	3.0	0.7	3.1	0.8

Table 70. Size variation of *Eremoblatta subdiaphana*.

	Length Body	Breadth Body	Length Tegmen	Breadth Tegmen	Length Pronotum	Breadth Pronotum	Length Eye	Interocular Distance	Length Cephalic Femur	Breadth Cephalic Femur	Length Middle Femur	Breadth Middle Femur	Length Caudal Femur	Breadth Caudal Femur	Length Caudal Tibia	Breadth Caudal Tibia
♂, JAL2, Aug. 3, 1961			13.7	5.5	3.0	4.3	1.45	0.5	2.1	0.5	2.6	0.6	2.7	0.85	3.2	0.5
♂, JAA11, Sept. 19, 1961			14.1	5.8	2.9	4.4	1.25	0.4	2.1	0.6	2.5	0.6				
♀, 6AA6, Aug. 21, 1961	10.9	6.3			4.0	5.0	0.5	1.6	1.75	0.5	2.4	0.8	2.7	1.0	2.8	1.0
♀, CBA4, May 6, 1961	10.7	6.3			3.0	4.6	0.65	1.2	1.7	0.5	2.1	0.6	2.1	0.8	2.2	0.65

The males are lighter in color on the cephalic margin of the pronotum. The wings, as in the species of *Arenivaga* at the test site, are semitransparent.

Distribution. A member of the Lower Sonoran faunal zone, this species is found on the deserts from California to New Mexico and extreme southwestern Texas. At the Nevada Test Site it was commonly distributed about Frenchman and Yucca playas.

Habitats. Specimens from the test site were collected in can traps and no data were collected as to their habits or habitats. They are undoubtedly nocturnal in that the males are attracted to lights at night. Their spined appendages suggest a burrowing habit and they may be associated with rodent burrows.

Seasonal Occurrence. Nymphs were collected as early as April 25 and were present into September. The adults appeared in May and were collected to September 19. They were most common during August and September and undoubtedly can be found into October at least.

Localities Represented. Specimens examined (nymphs and adults): 57.

Study 1B, 6 specimens, July 4 to August 28.

Studies 5A and 5CQ, 17 specimens, June 29 to September 19.

Study 6A, 2 specimens, July 3 and August 21.

Area 6, miscellaneous collecting, 4 specimens, August 28.

Study 10D, 3 specimens, July 11 to September 13.

Studies CBA and JA, 25 specimens, April 25 to September 19.

SUMMARY AND CONCLUSIONS

It is exceedingly difficult to present a clear analysis of any major group in a limited area, especially one defined by political boundaries. Certainly a complete revision of a group is needed to clarify any special relationships. This study is not an attempt at revision of any group, although some synonomy is suggested. From an evaluation of data derived from such studies, others can more correctly bring about the major revisions, and any ecologic or taxonomic study can only be used as an aid to major revisions.

The present study is the result of the combined efforts of many individuals. Approximately 8,000 specimens of Orthoptera were collected and studied during the course of the research. Taxonomically, this represents four of the five recognized suborders, the only suborder not present being the Notoptera, the grylloblattids. Eighteen families are found in North America; nine at the Nevada Test Site. A total of 41 genera and 60 species and subspecies were collected. Many of these are uncommon, however.

Two new species and one new subspecies are described, the distribution of some species is extended, and a few species are presented as being hypothetical to the test site in that they were not actually collected but may occur in limited distribution.

With each species is discussed the synonomy which has been previously established; the distinctive or comparative features, morphological and size variations, and notes on coloration. The

distribution of each species is given, overall and for the Nevada Test Site, both geographical and ecological, and the habits and habitats are presented where known. The seasonal occurrence given is not necessarily the earliest or latest for the species at the test site, but the dates when the insects were collected in nymph or adult form. The distribution of each species is presented for all localities, including the total number of specimens examined. A map plots the collection sites for each group.

An apparent scarcity of specimens for most species was apparent at the test site as compared to other desert and semi-desert areas. The reasons for this scarcity can only be speculated. It might be due to the normal fluctuation of numbers due to natural parasites, predators, or environmental conditions (i.e., wet seasons as compared to dry seasons). On the other hand, it could be due to radiation effects on the animals.

With reference to possible radiation effects, no statistical data were maintained to determine whether or not there is a high incidence of aberrant forms. There is a great deal of diversity in all orthopteran groups and the aberrant individuals may not occur with any greater degree at the test site than elsewhere. Radiation effects on a smaller population could conceivably produce the same results of normal speciation or subspeciation as over a complete range of distribution and in time.

An obvious environmental difference has been noted at the test site. In areas of complete destruction due to nuclear explosions few orthopterans are found, perhaps due to the scarcity of vegetation, particularly in the areas of short grasses and their associated vegetation. To the other extreme, an obvious benefit was noted as a result of an explosion on Rainier Mesa. In the disturbed area, where the rocks had been loosened and fissures of various sizes occurred in the ground, and the soil had generally been loosened, there were large numbers of most orthopterans, even though the dominant vegetation had been killed by the force. Few numbers were found in the comparative area where no nuclear effects could be noted.

The Orthoptera, as a group, are ideal indicator animals for radiation studies as have been and may be conducted at the Nevada Test Site. In addition to adequate numbers being present, both nymphs and adults are present at any season of the year. Most importantly, perhaps, the fossorial types, such as the species of *Ceuthophilus*, *Pristoceuthophilus*, or *Stenopelmatus*, may be protected in their underground environments, while species of *Trimerotropis*, *Ciholacris*, and *Litaneutria* may be more exposed in their terrestrial environment. In addition the winged species might actually migrate from one place to another. Finally, the thamnophilous forms, such as *Bootettix*, are never found on the ground and may react quite differently to or be exposed to different intensities of radiation.

Before any complete evaluation can be made with reference to numbers or radiation effects on the Orthoptera, a follow-up study should be made after a lapse of time.

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APPENDIX I

Depositories of Specimens Collected in This Study

American Museum of Natural History, New York City, New York.
Brigham Young University, Provo, Utah.
California Academy of Sciences, San Francisco, California.
Chicago Natural History Museum, Chicago, Illinois.
Dixie College, St. George, Utah.
Musuem of Comparative Zoology (Harvard), Cambridge, Massachusetts.
Nevada Southern University, Las Vegas, Nevada.
Philadelphia Academy of Natural Sciences, Philadelphia, Pennsylvania.
University of Michigan, Ann Arbor, Michigan.
University of Nevada, Reno, Nevada.
University of Utah, Salt Lake City Utah.
United States National Museum, Washington, D. C.
Utah State University, Logan, Utah.

APPENDIX II

Notes on Collecting and Preserving Orthoptera

Most Orthoptera are large and conspicuous and may be collected with a minimum of equipment, but at times with a great deal of effort. Some fossorial and terrestrial forms can best be found by the use of special can pit-traps or by searching through rodent nests and tunnels, in caves, or under rocks. At least one species is found associated with ants and requires special collecting. The thamnophilous orthopterans are best collected by the use of a heavy sweeping net, while the rapid fliers may be captured by dropping an aerial net over them after they have alighted on the ground. Nocturnal specimens may be collected at night, by looking for them with a light, or by locating them by their calls.

All winged specimens should be killed in a standard cyanide killing bottle, or by subjection to another gas, as fluids have a tendency to change body colors and make the wings unsuitable for adequate study. Fossorial specimens, such as the species of *Ceuthophilus*, *Pristoceuthophilus*, *Myrmecophila*, and *Stenopelmatus*, as well as the females of roaches (not the winged males), may be killed in 70% ethyl alcohol, in which solution they can be permanently stored providing sufficient fluid is present. A safe liquid volume for adequate preservation would be ten times the volume of the insects.

No specimen killed in the cyanide bottle should be retained in the bottle for more than four to six hours, as the cyanide gas discolors the specimens, turning them quite reddish. After death, but still relaxed, they should be pinned by forcing a No. 3 insect pin through the posterior part of the pronotum immediately to the right of the median carina. As most orthopterans are heavy-bodied, the legs and abdomen tend to sag. To correct this unsightly condition they should be allowed to dry for several days, according to environmental conditions (i.e., humidity), by inserting the pin in a sheet of styrofoam plastic covered with paper (to prevent their tarsi from breaking off when they are removed). The legs and antennae should be arranged in the desired position before drying.

The left wing of acridids, especially the so-called band-winged grasshoppers, those with brightly colored wings, should be spread on a spreading board to show the color and pattern of the wings, as these are important taxonomic characters.

Large specimens have a tendency to discolor due to body fluids, especially fats. These specimens should be eviscerated and the internal organs replaced with cotton; otherwise the specimens will turn dark and may decay. An incision should be made at the base of the ventral abdomen, the length of three segments and the internal organs removed with forceps. A small roll of cotton, the size of the internal abdomen, should be inserted to replace these organs. The natural size and color of the specimen is thus retained.

All specimens must be completely labelled with exact locality, date of capture, and environmental conditions. Specimens without complete data are of little scientific value.

Dried specimens must be kept free from dust and so-called museum pests. Fumigation may be accomplished by keeping a supply of paradichlorobenzene and/or naphthaline flakes in the box or case at all times. Specimens properly preserved and fumigated may be retained indefinitely.

APPENDIX III

Glossary

(Modified from Torre-Bueno, J. R. de la, **A Glossary of Entomology**, The Science Press Printing Co., Lancaster, Pennsylvania, 1937)

acicular, needle-shaped; with a long slender point.

acute, pointed; terminating in or forming less than a right angle.

adventive, accidental; applied to exotics or introduced species.

aedeagus, in male insects, the intromittent organ, a part of the phallic complex and situated beneath the pallium of the subgenital plate.

alate, winged; as opposed to apterous.

ambulatorial, fitted for walking.

annulus, a ring encircling a joint or segment.

apical, at, near, or pertaining to the apex of any structure.

apterous, without wings, wingless; see alate.

arcuate, arched; bow-like.

arolium, the terminal cushion-like pad between the claws of the tarsi.

articulate, to connect by a joint; jointed or segmented.

auditory, relating to the sense of hearing.

auricula (pl. **auriculae**), an appendage resembling a little ear.

brachypterous, with short or abbreviated wings.

bullate, blistered; a slightly swollen structure.

calcar (pl. **calcaria**), a moveable spur or spine-like process; specifically the spines at the apex of the tibia.

callosity, a thick swollen lump, harder than its surroundings; callus; also a rather flattened elevation not necessarily harder than the surrounding tissue.

campestrian, inhabiting open areas (fields).

carina (pl. **carinae**), an elevated ridge or keel, not necessarily high or acute.

carinate, keeled; having keels or carinae; with a, or several, longitudinal narrow raised lines.

carnivorous, feeding upon flesh food; an insect preying on other insects or feeding on their flesh.

caudal, of or pertaining to the anal end of the insect body.

cephalic, belonging to or attached to the head; directed toward the head.

cercus (pl. **cerci**), an appendage (generally paired) of the tenth abdominal segment, usually slender, filamentous and segmented.

cinereous, ash-colored; gray tinged with blackish.

clavate, clubbed; thickening gradually toward the tip.

clypeus, that part of the head of the insect below the frons (front), to which labrum is attached anteriorly.

coriaceous, leather-like; thick, tough, and somewhat rigid.

corneous, of a horny or chitinous substance; resembling horn in texture.

costa, any elevated ridge that is rounded at its crest; the thickened anterior margin of any wing, but usually of the forewings.

coxa (pl. **coxae**), the basal segment of the leg, by means of which it is articulated to the body.

crenulate (crenulation), with small scallops, evenly rounded and rather deeply curved.

cristate, with a prominent carina or crest on the upper surface; crested.

cuneiform, wedge-shaped; elongate triangular.

cursorial, adapted for running.

declivant, sloping gradually downward.
deplanate, compressed, flattened above and below.
dimorphism, a difference in form, color, etc., between individuals of the same species, characterizing two distinct types; may be seasonal, sexual, or geographic.
discoidal, relating to the disk, or middle; shaped like a round plate.
distal, near or toward the free end of any appendage; that part of a segment farthest from the body.
diurnal, active or habitually flying by day only.
dorsal, of or pertaining to the upper surface.

ecdysis, the process of casting the skin; moulting.
ensiform, sword-shaped; two-edged, large at base and tapering to the point.
epiphallus, a sclerite in the floor of the genital chamber proximal to the base of the phallus; pseudosternite.
epiproct, the dorsal part of the eleventh segment of the abdomen; the supra-anal plate.
explanate, spread out and flattened; applied to a margin.

falcate, sickle-shaped; convexly curved.
fascia (fasciation), a transverse band or broad line, especially when it crosses both tegmina or femora.
fastigium, the extreme point or front of vertex.
femur (pl. femora), the thigh; usually the stoutest segment of the leg, articulated to the body through trochanter and coxa and bearing the tibia at this distal end.
filiform, thread-like; slender and of equal diameter.
flavous, pure, clear yellow.
fossa, a pit or deep sulcus.
fossorial, formed for or with the habit of digging or burrowing.
foveola, (pl. foveolae), a deep depression with well-marked sides; a pit.
frons, the unpaired sclerite of the head lying between the arms of the epicranial suture and bearing the median ocellus.
furcula, a pair of backwardly directed appendages which overlie in a more or less forked position the base of the epiproct.
fuscous, dark brown, approaching black; a plain mixture of black and red.

gena (pl. genae), the cheek; the part of the head on each side below the eyes, extending to the gular suture.
genicular, pertaining to the curved dark markings on the posterior knee-joint.
genitalia, all the genital structures collectively.
geophilous, living on the ground; of species, living on the surface or coming freely into contact with it.
glabrous, smooth, hairless and without punctures or structures.
glaucous, sea-green; pale bluish-green.

herbivorous, feeding upon plant tissue; leaf feeder.
hyaline, transparent or partly so; waterlike in color; glassy.

immaculate, destitute of spots or marks.
instar, the period or stage between molts in the larva, numbered to designate the various periods; e.g., the first instar is the stage between the egg and the first moult.
interocular, between the eyes.

labium, the second maxilla; the lower lip; a compound structure which forms the floor of the mouth in mandibulate insects, behind the first maxilla and opposed to the labrum.
labrum, the upper lip, which covers the base of the mandible and forms the roof of the mouth.
lamellate, sheet- or leaf-like; composed of or covered with laminae or thin sheets.
laminate, formed of thin, flat layers or leaves.
lateral, relating, pertaininng, or attached, to the side.
linguiform, tongue-shaped; linear, with the extremities obtusely rounded.
lobulate, divided into, or with many small holes or lobules.

maculate, spotted or marked with figures of any shape, of a color differing from the ground color.
mandibles, the first pair of jaws, stout and tooth-like.
mandibulate, having biting jaws.
maxilla, (pl. maxillae), the second pair of jaws in a mandibulate insect.
medial, referring to, or at the middle.
mesad, toward or in the direction of the median plate of the insect body.
mesially, at or to the middle.
mesonotum, the primitively upper surface of the second or middle thoracic ring.
mesosternum, the underside or breast of the mesothorax.
mesothorax, the second or middle thoracic ring which bears the middle legs and the anterior wings.
metamorphosis, the series of changes through which an insect passes in its growth from the egg through the adult.

metanotum, the primitively upper surface of the third or posterior thoracic ring.
metasternum, the underside or breast of the metathorax.
metathorax, the third thoracic ring or segment, which bears the hind legs and second pair of wings.
metazona, the dorsal surface of the prothorax behind the principal sulcus.

nacreous, pearly; resembling mother of pearl.
nocturnal, of the night; applied to insects that fly or are active at night.
notum, the dorsal or upper part of a segment; tergum.
nymph, a young insect which quits the egg in a relatively advanced stage or morphological development, differing from the adult in having the wings and the genitalia present only in an incompletely developed condition.

obtuse, not pointed; at an angle greater than a right angle; opposed to acute.
occiput, the hinder part of the epicranium between the vertex and the neck.
ocellus, (pl. **ocelli**), the simple eye in adult insects, consisting of a single bead-like lens, occurring singly or in small groups.
omnivorous, feeding generally on animal or vegetable food, or on both.
ootheca, the covering or case over an egg mass.
ovate, egg-shaped in outline.
ovipositor, the tubular or valved structure by means of which the eggs are placed; usually somewhat concealed, but sometimes extended far beyond the end of the body.

palpus, (pl. **Palpi**), a mouth feeler; a palp.
paraproct, one of the two lobes formed by the ventrolateral parts of the epiproct.
penultimate, next to the last.
phallic complex, the genital structures of the male, especially the concealed structures.
phallus, the intromittent genital organ of the male.
plantula, a lobe of the divided tarsal pulvillus; one of the soles or climbing cushions of the foot.
pleuron (pl. **pleura**), the lateral region of any segment of the insect body, commonly of the thoracic segments.
pronotum, the upper or dorsal surface of the prothorax.
prosternum, the fore-breast; the sclerite between the fore-legs.
prothorax, the first thoracic ring or segment; it bears the anterior legs but no wings.
proximal, that part of an appendage nearest the body.
prozona, the anterior part of the pronotum.
punctate, set with impressed points or punctures.

raptorial, adapted for seizing prey; predacious.
reniform, kidney-shaped.
rostrum, in general, a snout-like prolongation of the head.
rugose, wrinkled.

saltatorial, adapted for leaping; having the power of leaping.
saxicolous, frequenting rocky or stony areas.
scalariform, ladder-like; applied to venation when the veinlets between two longitudinal veins are regularly arranged like the rungs of a ladder.
sclerotized, of the insect integument, hardened in definite areas by deposition or formation of other substances than chitin in the cuticula.
sellate, saddle-shaped.
serrations, a tooth, as of a saw; a series of such teeth.
serrulate, finely serrated; with minute teeth or notches.
seta, a slender hair-like appendage.
setaceous, bristle-shaped; slender, gradually tapering to a tip.
setose, furnished or covered with setae or stiff hairs.
spatulate, rounded and broad at the top; slender or drawn out at base.
spine, a multicellular more or less thorn-like process or outgrowth of the cuticula not separated from it by a joint; a large seta provided with a calyx or cup by which it is articulated to the cuticula.
spiniform, in the form or shape of a spine.
spinule, a small spine.
spiracle, a breathing pore; in the plural the lateral openings on the segments of the insect body through which air enters the tracheae.
spur, a spine-like appendage of the cuticula, connected to the body-wall by a joint.
sternite, the ventral piece in a ring or segment; a subdivision of a sternal plate, or any one of the sclerotic components of a definitive sternum.
sternum (pl. **sterna**), the entire ventral division of any segment; the underside of the insect thorax, between the coxal cavities.
stria (pl. **striae**), any fine longitudinal impressed line.
stridulate, to make a creaking, grating or hissing sound or noise, by rubbing two ridged or roughened surfaces against each other.

style, stylus (pl. **styli**), small, usually pointed, exarticulate appendages, most frequently found on the terminal segments of the abdomen.

subgenital plate, the plate or process underlying the genital organs; the terminal or distal abdominal sclerite.

suboecular, beneath or below the eyes.

suborbicular, slightly less than round and flat.

subterranean, underground, beneath the surface of the soil or ground.

sulcate, deeply furrowed or grooved; with deep grooves.

sulcus, (pl. **sulci**), a furrow or groove; a groove-like excavation.

supra-anal, above the anus; suranal; the epiproct.

suture, a seam or impressed line indicating the division of the distinct parts of the body wall.

tarsus (pl. **tarsi**), the foot; the jointed appendage attached at the apex of the tibia, bearing the claws and pulvilli; the distal part of the insect leg, consisting of from one to five segments or joints.

tectate, covered; concealed; tectiform.

tectiform, roof-like; sloping from a median ridge.

tegmen (pl. **tegmina**), a covering; the hardened leathery or horny forewing.

teneral, the condition of the adult insect after the last moult when it is not entirely hardened or fully of the mature color.

tergite, a dorsal sclerite or part of a segment, especially when such part consists of a single sclerite.

testaceous, bearing a test or hard covering; brownish-yellow.

thammophilous, living in thickets or dense shrubbery.

thorax, the second or intermediate region of the insect body bearing the true legs and wings, made up of three rings, named in order, pro-, meso-, and metathorax.

tibia (pl. **tibiae**), the fourth division of the leg, articulated at the proximal end to the femur and bearing on the distal end the tarsi.

trapezoidal, in the form of a four-sided figure of which two sides are parallel and two are not.

trigonal, triangular; an area bounded by a triangle.

trochanter, a sclerite of the insect leg, sometimes divided, between the coxa and femur.

truncate, cut off squarely at tip.

tubercle, a little solid pimple or small button.

tympanum, any membrane stretched like the head of a drum, specifically applied to the membrane covering the auditory organs.

ultimate, last.

undulate, wavy; obtusely waved in segments of circles.

ventral, pertaining to the under surface of the abdomen.

vertex, the top of the head between the eyes, frons and occiput.

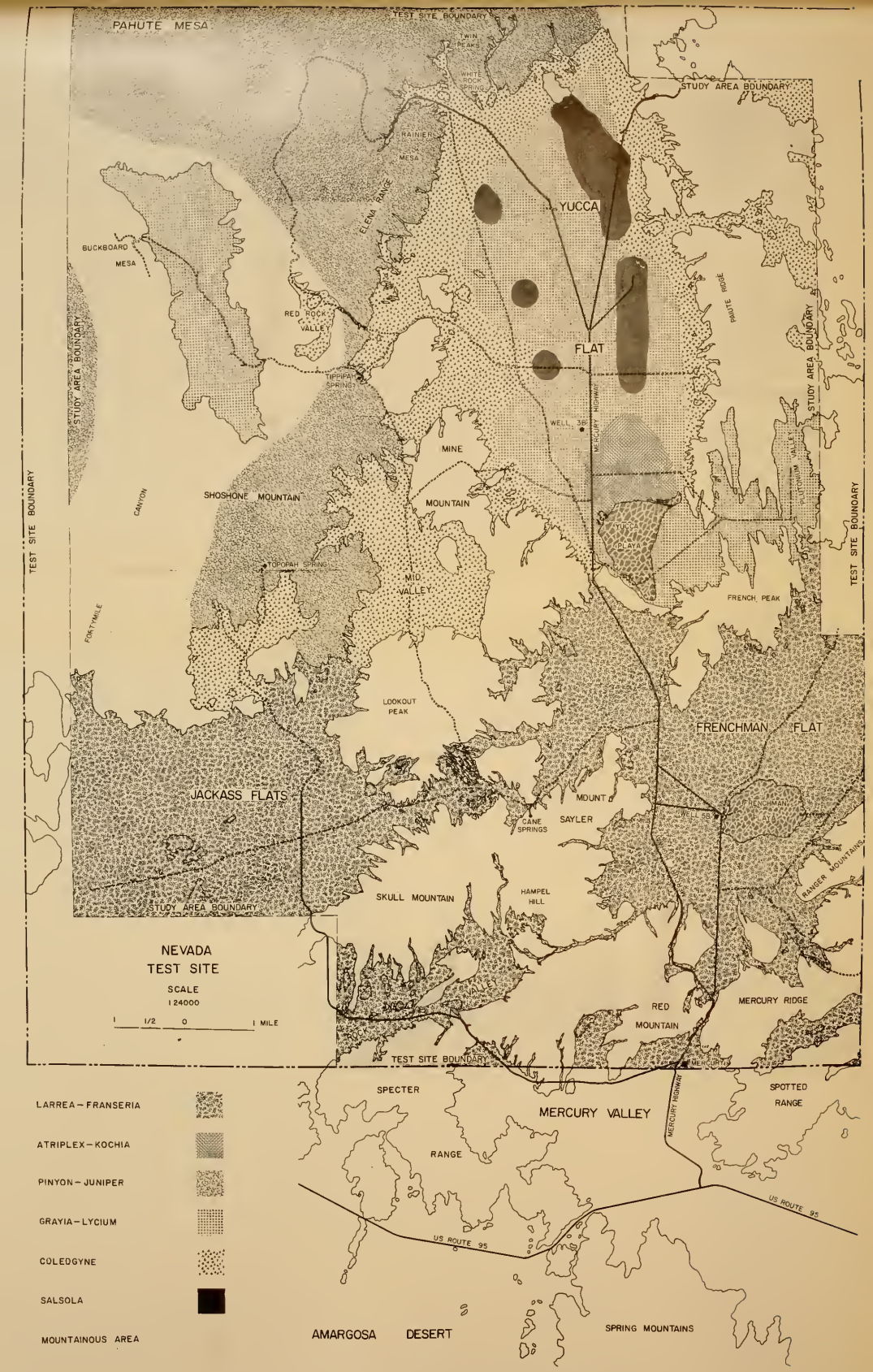

Fig. 44 Extent of the major plant communities at the Nevada Test Site.

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PRESETTLEMENT VEGETATION AND VEGETATIONAL CHANGE IN THREE VALLEYS IN CENTRAL UTAH

by

Earl M. Christensen and
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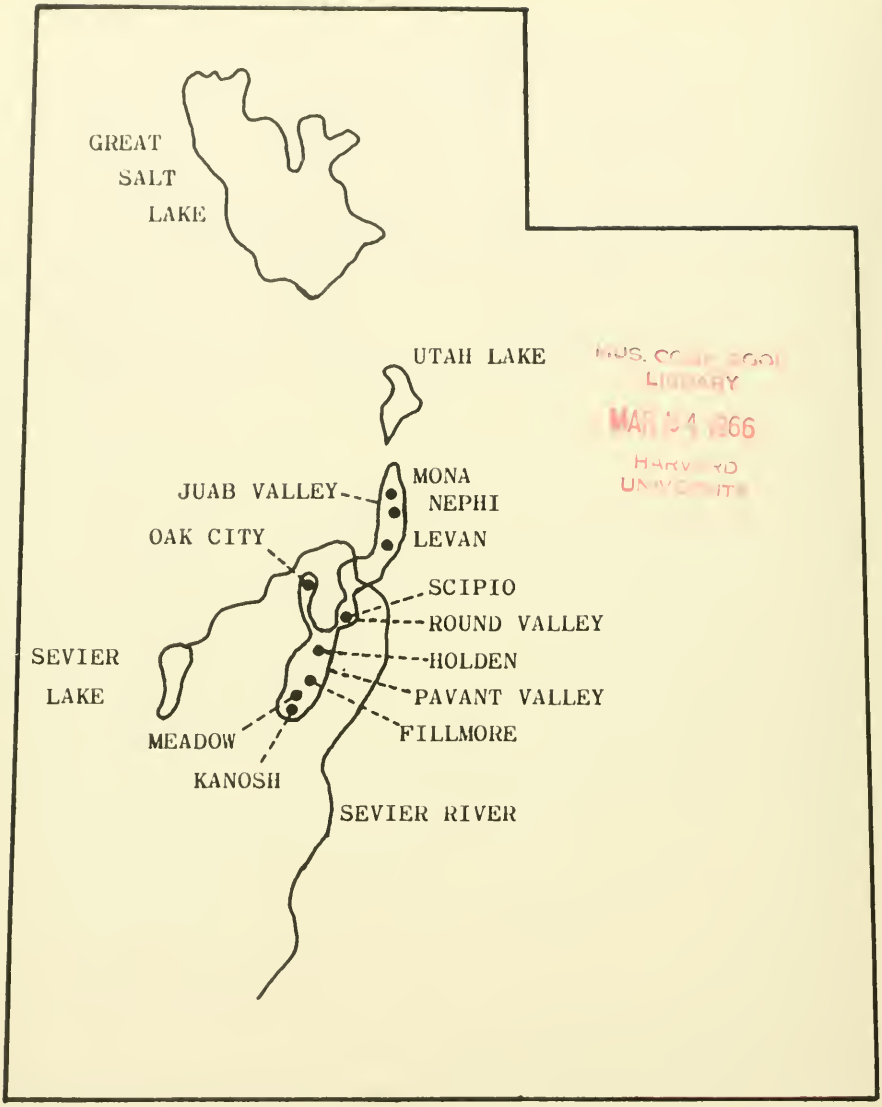

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FIG. 1.—Map of Utah illustrating the general locations of the valleys and towns discussed in the text.

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ABSTRACT

Historical information, survey records, and relict vegetation were used as sources of data for determining the nature of the presettlement vegetation of Pavant, Round, and Juab Valleys in central Utah. The foothills were covered with bunch grasses (principally *Agropyron spicatum* and *Poa secunda*), scattered junipers (*Juniperus utahensis*), and sagebrush (*Artemisia tridentata*). Western wheatgrass (*Agropyron smithii*) was common on level areas within the foothills. Below the foothill region on the more gentle slopes and benchlands there was a broad belt dominated by bunch grasses. The grassy area intergraded into a zone dominated by northern desert shrubs, particularly sagebrush. Grasses were conspicuous also in the northern desert shrub zone. In the valley bottoms, wet meadows and salt desert shrub communities occurred.

Significant changes in the presettlement vegetation had occurred by 1900. In general, there was a transition from a predominance of perennial grasses to one of sagebrush throughout the foothills and benchlands, and grasses became less abundant in the shrub communities. After 1870 juniper increased in density and invaded areas that were formerly dominated by grasses. These changes accompanied the use of these areas as range lands for livestock. In this century several exotic species have become important components of the vegetation.

The rates of migration since 1870 of two groups of unstable sand dunes in Pavant Valley were determined to be 53.5 and 60.9 feet per year.

PRESETTLEMENT VEGETATION AND VEGETATIONAL CHANGE IN THREE VALLEYS IN CENTRAL UTAH

INTRODUCTION

Marked changes have occurred in the native vegetation in Utah valleys since settlement by the white man. Various aspects of these changes have been described by Utah biologists: Cottam 1926, 1929, 1945, 1947, 1961a, 1961b; Pickford 1932; Wakefield 1933, 1936; Bailey, Forsling and Becraft 1934; Cottam and Stewart 1940; Stewart, Cottam and Hutchings 1940; Tanner 1940; Stewart 1941; Stoddart 1941, 1945; Cottam and Evans 1945; Christensen 1950, 1962, 1963a, 1963b; Christensen and Welsh 1963; Mason 1963. In general these studies show that the vegetational changes have been particularly impressive in those areas of the foothills and valleys originally dominated by grass. Considerable change has also occurred in the pinyon-juniper woodland and mountain brush communities of the foothills and lower mountain slopes. Similar vegetational changes are documented for the valleys considered in this report.

In this paper a general description of the presettlement vegetation is given for three valleys in central Utah: Pavant, Round, and Juab Valleys. In addition, an outline of the gross changes of the vegetation of these valleys since settlement is given. The vegetation of the mountains surrounding the valleys is excluded for the most part from this discussion, the emphasis being placed on the vegetation of the foothills, benchlands, and valley floors.

Historical publications, pioneer journals, diaries of explorers, previous ecological studies, and survey records were searched for information. In addition, residents were interviewed and relict stands of vegetation were studied.

Pavant and Round Valleys are in the eastern part of Millard County, and Juab Valley is in the eastern part of Juab County. The towns of Kanosh, Meadow, Fillmore, and Holden are in Pavant Valley; Scipio is in Round Valley; and Levan, Nephi, and Mona are in Juab Valley. The Oak City area adjacent to Pavant Valley is also considered in this paper (Fig. 1).

Pavant Valley is bounded on the south and east by the Pavant Mountains, on the north by the Canyon Mountains, and on the west by the Black Rock and Sevier Deserts. Round Valley is bounded on the west by the Canyon Mountains, on the south by the Pavant Mountains, and on the east by the Valley Mountains. To the north there is a pass into Juab Valley. Juab Valley is bounded on the southwest by the Canyon Mountains, on the west by the West Hills and Long Ridge, on the east by the Wasatch Mountains and the San Pitch Mountains and on the south by the Valley Mountains. To the north there is a pass to Utah Valley.

PRESETTLEMENT VEGETATION

Records and Journals of Explorers and Early Residents

Pavant and Round Valleys. Descriptions of the vegetation of these valleys were made in varying degrees of detail by several early explorers and pioneers. The first of the explorers was Escalante, who travelled through central Utah in the fall of 1776 (Auerbach 1943). His party camped in Round Valley on September 30. He described Round Valley as a "plain with abundant pasture but without water" (p. 73). Leaving Round Valley, Escalante travelled west and south, essentially missing Pavant Valley. However, he described the xeric vegetation of the saline areas west of Pavant Valley.

In May of 1844 John C. Fremont and party passed through the Pavant Valley (Nevins 1956, p. 417). His path led him close to the Pavant Mountains. He wrote:

> We had now entered a region of great pastoral promise, abounding with fine streams; the rich bunch grass—soil that would produce wheat and indigenous flax—growing as if it had been sown. Consistent with the general character of its bordering mountains, this fertility of soil and vegetation does not extend far into the Great Basin.

Local pioneers and California-bound emigrants made notes of their impressions of the area. Sheldon Young, travelling south with gold seekers bound for California, noted "some pleasant valleys" and "plenty of hares" after crossing the Sevier River on October 12, 1849 (Hafen and Hafen 1954, p. 64). In Pavant Valley he observed:

> . . . good roads, plenty of grass, wood and water. . . . There is a quantity of wild flax.
> . . . Went 12 miles [Kanosh area] . . . . Beautiful roads and plenty of grass and water.
> . . Eight miles from camp . . . plenty of grass. This is the most pleasant valley that we have passed through

Young observed "Grass very good" at the southern part of the Pavant Valley.

Addison Pratt, travelling with the same company, made comments about Round and Pavant Valleys (Hafen and Hafen 1954, pp. 72-73):

> . . . The hares are so plentiful here [Scipio] that the ground would well compare with a sheep pasture. . . . As the valley was covered with grass except the farther side, there was plenty of sage brush and when we entered the hares commenced in every direction. . . . We then had a mountain to ascend and descend. We camped on Cedar Creek [Holden]. Here was plenty of dry cedar wood.
> [Near Fillmore] the hunters surrounded a large sagebrush. . . . The bottoms are covered with dwarf cedars.
> 15th Travelled 12 miles and camped on Willow Flats [near Kanosh] here are low prairies covered with immense quantities of grass. Hares continue to be plentiful.
> 16th Passed over some beautiful rich bottoms covered with green grass which is uncommon at this season of the year. . . .

William Farrer also made observations on the vegetation of Round and Pavant Valleys in October of 1849 (Hafen and Hafen 1954, pp. 195-196):

> . . . we came into a large wide Canion feed growing very luxuriently. we came into an extensive Valley little water sage Brush plentiful feed prety good . . . .
> . . . crossed another wider creek a little timber growing on it. traveled thro a good deal of Sage. . . .
> . . . we passed through a fine path of Rye grass in this valley . . . struck a creek with some little timber in it but very little grass. . . . Camped on the bluff . . . feed rather thin but a good kind of grass called mountain bunch grass.

Joseph P. Hamelin, Jr., made an overland trip to California in 1849-50, passing through Juab, Round and Pavant Valleys (Hafen and Hafen 1961, p. 82). On November 14, 1849, he recorded the following:

> Leaving the Sevier [River] we ascended by a gradual slope of nearly 3 miles to the summit of a cedar covered mountain. Keeping along the ridge for a short distance we descended to and crossed a beautiful valley seven miles in width. . .
> [He] Travelled down the valley of Sevier Lake [and found the] Road good, though mixed with wild sage, any quantity of fine grass. The men killed any quantity of sage hens & large hare.

In January of 1850 Parley P. Pratt entered Pavant Valley from the south on his return to Salt Lake City from southern Utah (Richan 1957). He described the Meadow area of Pavant Valley as "a low well-watered valley of meadows and soil." He camped at "Prairie Creek" (now called Meadow Creek) near the town of Meadow. When Pratt camped on Chalk Creek in the vicinity of Fillmore there were 18 inches of snow on the ground, and he recorded "nothing for the cattle to eat, except a little browsing among the willows." He "found plenty of cottonwood fuel" on Chalk Creek. Pratt further described the area as follows:

> It was in a country of shrub cedars which would afford some shelter for the animals, and richly clothed in bunch grass, and some portions of the hill sides where the snow had blown off being nearly bare, the cattle could live.

The following winter (late December 1850 and early January 1851), George A. Smith and company passed through this region going south (Smith 1956). After leaving the Sevier River on December 27 he stated:

> . . . Camped in a beautiful valley [Round Valley]. Snow 12 inches deep. Good feed, bunch grass, plenty sage brush and cedar within half a mile, but no water.

Six miles north of Holden the company "camped in a little basin near some cedars" and the next day "passed through several deep ravines and scattering cedars" while travelling to Holden. "Good water and plenty of bunch grass" was observed along the way.

Between Holden and Fillmore the company

> . . . passed through a pleasant country dotted with cedar, some excellent spots of land covered with rich bunch grass. Arrived at Camp Creek [Chalk Creek] at 4 p.m. Some few cottonwoods scattered along its banks. I sent men to see if there was any timber suitable for bridging the creek. But they reported unfavorably the wood being too small for that purpose. . . . Our cattle fared sumptuously on bunch grass.
> [The company] moved on to Meadow Creek, distance 11 miles. The road was level, passing through a plain of sage. . . . Here we are on a rich strip of land and abundance of

grass. . . . Brother Shirts went down Meadow Creek for about eight miles hunting deer. He reported some cottonwood on the creek stream rapid, and as large as that of Camp Creek [Chalk Creek]. It sinks at this place and forms a large meadow, excellent soil of a dark reddish color.

. . . Br. Peter Shirts went up the Creek hunting deer. Found the land excellent all the way except about ½ mile of sage brush. Went up the mountain . . . about 3 miles. He could see the open valley as far as the eye could extend, also a lake, which he thinks is 70 miles long and many bodies of cedars on the plains.

Smith's company camped near Kanosh on Corn Creek. Smith reported:

. . . This country is capable of sustaining a very extensive settlement. About 2 miles from Corn Creek we passed a fine running stream, with rushes on each side. Br. Shirts went up Corn Creek 6 miles and reported abundance of excellent land; also iron ore and other mineral rocks, abundance of cedar and oak and some maple.

Leaving Kanosh the company went into the hills at the south end of Pavant Valley through a cedar grove and camped at the mouth of a canyon. "There cattle feasted on bunch grass and frost. There was no water."

In March and April, 1851, Parley P. Pratt made his second trip through the area (Stanley and Camp 1935, pp. 62-63). He described the early springtime:

[From Sevier River to Scipio he] Traveled 13 m.s. through a pass where the hills were verry rich in grass and fewel. . . . Thence through a valley [near Scipio] rich in grass and soil. Beautiful and extensive and abundantly supplyed with fewel on its borders. . . .

. . . encamped at a beautiful spring brook [Holden] among grassy hills interspersed with cedar like an orchard. Our road today led through a pass in the mountains by a gradual assent of 3 m.s. and then down verry gradually for 10 miles. Among hills, plains and little vales, more rich in bunch grass and cedar fewel and more varied and beautiful than any other country I ever beheld in the State or in these mountain countries. Every high hill, every dell, every vale or knook seemed thickly coated with a living green of rich grass and set about with cedars from 12 to 25 feet high like an old orchard.

Wennesday, April 2d. On the east the high mountain chain [Pavant Range] appeared at several m.s. dis. snowy and timbered and pierced with gorges accessible for roads to be made to the timber. . . . To our South, West and North west the view is Almost Boundless, Consisting of a vast valley [the Sevier Desert] interspersed with fertile meadows, desert spots, known by their darker hew, lakes, rivulets distinguished by the yellow meadow grasses and red willow streaks and hills here and there, dotted with cedars and the whole bounded in the vast dim distance by dark mountains, not verry high. . . . There are resources for farming, stock raising, fewel, etc., in site of our present encampment probably more than sufficient to sustain the present population of Rhode Island. . . .

. . . we at length left the valley and journeyed 26 m.s. over a hilly country well supplied with cedar and scrub pines, for fewel and bunch grass for feed. . . .

Later in the year, October 1851, a party accompanied by Brigham Young set out to locate the site of Pavant Valley's first settlement (Cooley, 1955). The following report was prepared and sent to the territorial legislature as a result of this exploration. Orson Pratt, Albert Carrington, Jesse W. Fox, and William C. Staines signed the report. The site chosen for the first settlement later became Fillmore, the first territorial capital.

Pauvan is a very large, fertile valley, reaching northwesterly across the Sevier [Desert], & Southeasterly to the Cañon of Corn Creek [near Kanosh]. . . . This large area presents a rich & picturesquely diversified landscape; the table lands, & their rounded points being thickly studed with cedar, & the beauty of the valley proper increased by low, short ranges of hills & isolated mounds, with the dark shade of their cedars ever richly contrasting with the lighter green of the summer, or the paler hue of the Autumn grass that waves so abundantly & luxuriantly over the remaining level, and very fertile portions. . . .

On April 30, 1853, Anson Call, the leader at the Fillmore settlement, published a letter in the *Deseret News* dated March 27, 1853 (Call 1956, p. 98). In it he stated:

. . . Our stock have wintered well, universally, many of our cattle were driven through from the states last season and have improved in flesh on the range and I do not know of the first head being lost. We think our valley is not surpassed for range in these mountains.

In October of 1853 a party of explorers headed by Captain J. W. Gunnison passed through the area. A report of the expedition was prepared by Beckwith (1855). While in Round Valley, Beckwith wrote (p. 71):

. . . Sage grows luxuriantly. . . . The range is finely covered with grass quite down to the sage plains, and is dotted with a growth of small cedar and oak, and is a fine pastoral district.

The group camped at Holden (pp. 71-72) and then travelled northwest toward the Sevier River. The following day they

> reached the Sevier river at a point well supplied with dry grass, which our animals required after a march of 25.43 miles, on which we were engaged for twenty-two hours, over large, rank sage-brushes and a friable soil, occasionally sandy. Indeed, this whole valley, some fifty or sixty miles in diameter, is one vast artemisia plain surrounded by grassy mountains.

Captain Gunnison and part of his company were killed by Indians. The remainder of the company later returned to Holden by a different route. From a point north of where they first encountered the Sevier River, they travelled

> . . . 7.44 miles in a southeast course, beyond a border of small cedars a mile wide, among which the sand was so drifted that it was only by innumerable windings and contortions of teams and wagons, that we at last escaped from it and reached the plain of grass a mile or two wide, which lies on the gradual slope of the mountain [Oak City area].

In 1855 Linforth made descriptions of parts of Utah based on a variety of sources, many of which were not given. He described Round Valley (p. 99) as being "well grassed" and with "well wooded" mountain slopes. Concerning Pavant Valley, Linforth wrote (p. 99):

> . . . its forests of cedar extend into the plain, and it has all the varieties of soil and landscape, from the lofty mountain and rich valley, to the level plain and bleak desert. The Kanyon of Chalk Creek . . . contained an extensive supply of red and white pine timber . . . the hills and plains are covered with bunch grass.

The Frenchman, Jules Remy, and his party passed through the area in late October of 1855 (Remy 1861, p. 340). Remy described Round Valley as "a desert and barren plain, where our cattle had nothing to eat but the bread and corn we gave them." However, the northern part of Pavant Valley was described as being "a valley of much less dreary aspect than those through which we had been for some time passing." Remy noted that in the mountain brush zone, "Oaks, wild rose-trees, *Cowania*, *Juniperus*, covered the edges" of Pavant Valley, and observed "numbers of hares and grouse were to be seen skimming away from us under these stunted trees." It is evident from the following statement that the treeless areas of the valley benchlands and bottoms were considered "barren" of vegetation by Remy:

> . . . On leaving the valley we found ourselves upon an open piece of ground, from which we could see on all sides well wooded mountains contrasting strongly with the bareness we had of late been used to. The sight before us was certainly not worthy of being sung by a poet, but for Utah it was a landscape extraordinarily picturesque and even fertile. . . .

Remy listed scientific names for woody species of the region, but his descriptions of the vegetation in general are not as detailed as many of the other descriptions made of the area. This is particularly true of the treeless parts of the valleys.

In late December, 1866, William H. Jackson, the frontier photographer, passed through the region (Hafen and Hafen 1959, pp. 104-105). He spoke of going through Round Valley and into Pavant Valley:

> . . . all the way up over the Divide down into Round Valley. . . . Poor chance for water & wood. Used sage. Plenty of cedar in the hills we passed.
>
> . . . Pulled up over high rolling hills pretty well covered with cedar to Cedar Creek [Holden], some 10 miles. Any quantity of wood. . . .

On Christmas Eve, 1867, Clampitt (1890) travelled from the Sevier River to Round Valley. He described the vegetation of the area (p. 351):

> After crossing the Sevier our road led to the uplands, and our course was quite hilly. In these higher altitudes snow had mingled with the rain, and the ground was covered with quite a depth. This was a grazing country, and herds of fat and lean cattle were seen at intervals. I now beheld the novel sight, new to me at that time, of the cattle feeding on the short, sweet and dried buffalo grass, with which the hills abounded, all of which was beneath snow. The cattle would plant themselves firmly on their hindquarters and with their fore legs paw the ground swiftly, causing the snow to fly in a silvery spray and rapidly uncover the ground, exposing the grass upon which they would feed. All winter long they sustain themselves upon this dried grass, which is truly nutritious. Cattle that have been worked thin and poor from hard continuous labor through the spring summer and fall months are, at the close of the season, turned out to graze all winter upon the grass, and in the spring are returned to their work fat and sleek and strong.

Powell (1879) described the area drained by the waters which flow into the Sevier Lake (p. 106):

> In the valleys among the high plateaus, and along their western border, the grasses are good, and many pasturage farms may be selected . . . . The summits of the plateaus will afford an abundant summer pasturage.
>
> Westward among the Basin Ranges . . . there is little timber of value, but the lower

> mountains and foot hills have cedar and piñon pines . . . . The cedar and piñon hills bear scant grasses. The valleys are sometimes covered with sage, sometimes with grease wood, sometimes quite naked.

George C. Yount travelled through Utah territory in 1830 and spoke of passing through some pleasant valleys in the central part of the state (Camp 1923). It seems probable, however, that he never entered Pavant Valley but travelled south along the Sevier River Valley, the valley east of the Pavant Range.

Juab Valley. On September 27, Escalante (Auerbach 1943, p. 71) described Juab Valley as

> . . . fourteen leagues from north to south, and about five from east to west. The whole of it is flat; it has very abundant springs and pastures. . . .

The southern part of Juab Valley was described as "a valley of good pasturage" by Escalante, and he also noted the "small glades and barren hills" of the vicinity. The northern desert shrub type of the area near the southern end of Juab Valley was observed as "a plain covered by chamiso thickets, very annoying to the animals" by Escalante (Auerbach 1943, pp. 72, 73).

Based on a study of early historical information Worthington (1958, p. 3) described the presettlement condition of Juab Valley in the following way:

> Before the coming of permanent settlers Juab Valley presented a very beautiful appearance. Wherever water was abundant, and this included most of the valley with the exception of what is now Levan Ridge, there was beautiful grass waist high. The hills were covered with green vegetation and cedar trees. Higher up on the mountains were maple, pine, and quaking aspen. . . . Toward the west mountains in the valley was, of course, much sage and rabbit brush. . . .

In 1844, Fremont described Juab Valley as "a handsome mountain valley covered with fine grass" (Nevins 1956, p. 418), and Sheldon Young observed "Plenty of grass" in Juab Valley in 1849 (Hafen and Hafen 1954, p. 63).

William Farrer journeyed through Juab Valley in October, 1849, entering the valley from the north. He mentioned the "prairy" and "very little timber" in the valley. He also made the observation that "the hills were covered with scrub Cedar" (Hafen and Hafen 1954, pp. 194-195).

Martha Spence Heywood described the streamside vegetation of Salt Creek near Nephi in 1851 as "beautifully adorned with trees according to my heart's desire" (Worthington 1958, p. 16).

In March of 1851 Parley P. Pratt described the Mona area in the northern part of the valley as "rich in grass" and noted that "the hills, valies, and table lands [of Juab Valley] afford some cedar fewel, and vast resources for pasturage." On March 27, 1851, Pratt travelled for 15 miles south of Nephi "over a smooth swell of land without water but bordered by beautiful hills of bunch grass and cedar fewel, and encamped on a spring run, which gives rise to a swail, or swampy meadow." Pratt was obviously travelling along Levan Ridge between Nephi and Levan. He camped on the banks of the Sevier River on March 28 and recorded: "This day we passed through about 10 m.s. of waste country, with some grassy spots and Cedar groves." After crossing the Sevier River, he wrote: "The hills afford some scattered bunch grass which is very good" (Stanley and Camp 1935, pp. 61-62).

Addison Pratt camped on the Sevier River on October 9 and 10, 1849, writing about the country as "a barren waste covered with sage brush save the river bottoms which are covered with grass, on the hills were a few dwarfish cedars" (Hafen and Hafen 1954, p. 71).

After travelling through central and southern Utah in 1849, Granger (Hafen 1959, p. 14) described the valleys along what is essentially the modern Highway 91 in the following manner:

> From the valley of the Great Salt Lake to the Santa Clara [in southwestern Utah], is a succession of little vallies abounding with rich grasses; along the line of the great Wasatch range, which takes a southerly course.

Linforth (1855, p. 98) described Juab Valley as "a long, moderately wide, and well-grassed valley."

In the fall of 1855, Remy (1861, pp. 336-337) "journeyed across a desert plain, part of a large valley enclosed between barren hills [Juab Valley]. On our well-worn track was to be seen at intervals a species of mallow with pretty flowers of a pale red. In the plain nothing was to be found but *Artemisia, Fremontia,*[1] and Greasewood." Remy camped on the banks of Chicken Creek in the southern part of Juab Valley in a "dried-up pasture," stating that "It was impossible, though we went some distance for it, to find even the least brushwood to make a fire with." In the creek "specimens of *Chara, Polygonum,* and *Hippuris*" were observed.

[1]*Fremontia* is an old name for greasewood, *Sarcobatus vermiculatus.* Remy uses "Grease-wood" in reference to *Opuntia* cactus (p 503).

The botanist Tracy (1888, p. 26) described the vegetation near Juab, Utah, in August 1887:

> On the mountains, 8 miles east, *Agropyrum* [sic] *divergens*[2] is one of the prevailing species. The range here is said to be much more barren than it was five years ago, prior to the introduction of sheep. West of the town there are barren, treeless hills, with scanty growth of the above-mentioned grass, together with *Oryzopsis cuspidata*.[3] White sage[4] (*Atriplex*) is the main reliance for winter range.
>
> . . . Considerable Redtop is found on the lower lands and *Agropyrum divergens* and *Erodium cicutarium* are found to some extent. [Redtop and *Erodium cicutarium* are introduced species.]

Recollections of Early Residents

In addition to the on-the-spot observations recorded in journals, reports, and diaries, information was obtained through personal interviews and from recorded recollections of old-time residents. The following is an unpublished statement which was given to James Jacobs, Forest Service, in 1947 by Hyrum Bevan Johnson, an early pioneer of Holden:

> My parents, Mr. and Mrs. Richard Johnson, were sent down here to Holden (then Cedar Springs) in February, 1856, and started building the rock fort (Buttermilk). I was born in the corner of the fort where my home now stands on June 5, 1856. I have lived on that same spot all my life.
>
> I have been around livestock all my life, and worked with them most of it. I remember how the range looked. When I was a boy the flats were covered with bluegrass in a good sod. There was a little sagebrush in them, but scarcely enough to stake a horse to. (We would often stake a horse which we would use for a wrangle horse.) The foothills were covered with bunchgrass. It was not what we called wheatgrass, but was shorter and much finer. There was also a lot of sand grass [*Oryzopsis*]. The foothill bunchgrass grew about two feet high in places. When I rode my pony through it, it was tall enough to tickle my bare feet. There was a little sagebrush, but not much.
>
> They used to cut hay on the meadows at Clear Lake 20 miles west of Holden, seven miles west of Holden, and over at Scipio Lake. Some bluegrass was cut on flats near Holden, but this did not yield enough. The hay was cut with scythes. There was only a very little hay put up for many years as the grass was so good that the stock could get all the feed they needed.
>
> When I was about 12-15 years old [1868-1871] the church sent about 1000 head of cattle and about 75 horses from the islands of Great Salt Lake and grazed them on this good grass . . . The grass was so good that the cattle were fat all winter. We could get a beef any time. As the grass was grazed off and killed out, sagebrush came in.
>
> There were many sheep here in the early days, which ranged here year long. My brother and I used to run the co-op herd on shares. About 1880 there were 20,000 sheep here. . . . Many sheep would come from Sanpete and some as far as Salt Lake . . . . There were 1500 to 2000 cattle here then. The cattle did not run upon the high mountains—that was all used by sheep. There were many bands of outside sheep, but not many of those were on the mountains. That was used by other local sheep.

William Hardin Ashby came to live in Holden in 1872. Previous to this he had spent several years of his life working for the Mormon Church as a cowboy. In reward for his services Brigham Young gave him a choice of receiving the church farm in Cache Valley in northern Utah or the Church Spring north of Holden. Hardin's son Robert related the following (Ashby 1944, p. 27):

> Father was familiar with the Church Farm in Cache Valley, and he went to Holden to look things over there. He found the valley around Holden a waving field of blue grass. Some of the people were mowing it for hay. To a cowboy this spelled paradise—so the choice was Holden. Years later when Millard was found to be so dry and the grass failed to wave like harvest grain, Father always said he made a poor choice.
>
> He was allowed besides the Church Spring property, a forty-acre piece of meadow hay land, 8 miles west of Holden (which during the next few years was buried by drifting sand hills). . . .

Robert L. Ashby (1955-56, pp. 11-12) described his impression of the original vegetation near Holden in his *History of Holden, Utah*:

> The name Cedar Springs suited the place well, and but for the tragedy of Eligah Edward Holden's death in 1858, this likely would have been the permanent name of the town. There were numberous springs around the foot hills, and Cedar trees grew most everywhere. The hills and valleys were covered with grass—mostly a native close-sodding blue grass. This grass served well for feed for their animals. Some was cut and stacked for winter use. Sage brush grew throughout the region.

The meadow land seven miles west of Holden was important in the early history of Holden:

> Near these sand dunes was pioneer Hay Ground. Here rainbow grass and various water grasses grew in abundance and made most beautiful meadows. Water holes filled with tiny minnows dotted the meadows. . . .
>
> This was the valley where the Church in these early days brought vast herds of cattle.

[2]Old name for bluebunch wheatgrass
[3]Indian rice grass
[4]Probably *Atriplex confertifolia*, shadscale

Armina S. Nixon, an old resident, recorded the following in her history of Holden (Day and Ekins 1951, pp. 290-291):

> The hills and valleys in this section were covered with grass which served as feed for their cattle, horses and oxen. It was cut and stacked in the summer and fall for winter feeding.
>
> . . . All west of that [present Highway 91] was grass and sage brush. What is now the meeting house grounds was covered with cedar trees, sage brush and grass.

Day and Ekins (1951, p. 6) record that herders were hired the "first summer to herd the stock on the wild grass seven miles west of Fillmore."

The following conditions of the vegetation and range in 1867 were reported in the *History of Oak City* (Day and Ekins 1951, p. 475):

> At that time the flat where the town was later built was covered with grass so thick that it waved like a field of grain. . . .
>
> The brethren there [Deseret City] have adopted a wise policy in related to keeping stock. They have all their animals not in use herded some twenty miles northeast on a good herd ground [Oak City area]. . . .

Analysis of 1869-70 Survey Data

Government surveys (Bureau of Land Management) were made in portions of this area in 1869 and 1870. The field records of ten townships located in the Holden-Fillmore area of Pavant Valley were studied and were found to contain some interesting vegetational information. The description of almost every section line ended with a comment on the soil and the vegetation occurring along the line. Designations such as "soil second rate, rolling grassland" and "soil second rate, level, sagebrush greasewood" were used. The information from these records was copied and then transferred in color code to a map for analysis.

It is interesting to note that of the 363 section lines analyzed, 102 (28%) had grass listed as being the most conspicuous plant. Two hundred and fifty-eight (71%) had sagebrush growing either abundantly or scattered along them. Eighty-nine (25%) had greasewood. Cedar (juniper) occurred in 12 (3.3%). A small number, 10.5 (2.7%), were under cultivation. The lines surveyed where vegetation was not mentioned numbered fourteen. The surveys did not extend far into the foothills or more grassland would surely have been recorded. Almost two-thirds of the grasslands surveyed were of the wet meadow type occurring in the valley bottom.

The following is a generalized description of the distribution of the plant communities of northern Pavant Valley based on the survey data. Near the base of the Pavant Range, just below the juniper-covered foothills, a zone of grassy plains occurred. The grass was sometimes in pure stands but more often had occasional or scattered sagebrush. Farther into the valley away from the mountains there occurred a zone dominated by sagebrush. In some places sagebrush was conspicuously the leading dominant. In other places considerable grass was present even though the sagebrush was the most conspicuous species. This is concluded because in the general description of some brush-covered townships the statement is made that the area had high grazing value, even though no mention is made of grass in the section line descriptions. Greasewood and sagebrush often occurred in the same general area. Wet meadow vegetation was located in the lowest parts of the valley.

Relict and Protected Areas

Christensen (1963a) studied 71 small foothill grass stands in the central Utah region (in-

Table 1

QUANTITATIVE DATA FROM A PROTECTED AREA AT MONA CEMETERY, JUAB VALLEY, UTAH.

Percent composition based on foliage cover determined by the line intercept method. Percent frequency and density were determined from quarter milacre quadrats.

Species[5]	*Percent Composition*	*Percent Frequency*	*Density Per Quadrat*
Agropyron spicatum (bluebunch wheatgrass)	87.3	100	7.0
Poa secunda (Sandberg bluegrass)	5.5	92	7.4
Sphaeralcea coccinea (globe mallow)	1.8	52	2.9
Phlox longifolia (phlox)	1.6	36	6.8
Artemisia tridentata (sagebrush)	1.0	2	0.02
Gutierrezia sarothrae (snakeweed)	0.7	0	0
Chrysothamnus viscidiflorus (rabbitbrush)	0.6	4	0.08
Bromus tectorum (cheatgrass)	0.3	8	0.1
Other species	1.2	—	—
Foliage cover (all species)	44.6		
Density per quad. (all species)			26.3

[5]Nomenclature follows Holmgren, A. H. 1948. Handbook of the vascular plants of the northern Wasatch Lithotype Process Co., San Francisco, Calif. 202 pp.

cluding the area considered in this paper) that were judged to be undisturbed essentially. Perennial grasses made up 73.8 percent of the vegetative cover of these communities. Sagebrush and other woody species accounted for 20.5 percent of the cover, and broadleaf herbaceous plants made up 5.7 percent. Pickford (1932) studied nine plots in the foothills from southern Utah Valley to Beaver City that had been protected for several years. Composition data for the 9 plots were presented and Pickford stated:

> Perennial grasses, principally blue bunch wheat, beardless bunch, blue stem wheat (*Agropyron smithii*), Sandberg's blue, and rice grass (*Oryzopsis hymenoides*), with a density of 0.19 occupy 56 percent of the total plant cover. Downy brome and good perennial weeds are relatively unimportant representing only 4 percent of the plant cover respectively. Poor perennial and annual weeds, principally globe mallow, phlox (*Phlox longifolia*), sunflower, milk vetch (*Astragalus* sp.) and wild lettuce; sagebrush, and shrubs other than sagebrush, principally rabbitbrush (*Chrysothamnus* sp.), gambel oak (*Quercus gambelii*), bitterbrush and serviceberry (*Amelanchier alnifolia*), occupy 13, 12, and 11 percent of the plant cover, respectively.

The eastern part of Mona Cemetery has been protected to a considerable degree from disturbance, although some woody plants may have been removed from the stand. In 1956 this relict stand was studied by means of line intercept and quadrat methods. The composition data are presented in Table 1.

DISCUSSION — ORIGINAL VEGETATION

A generalized description of the presettlement vegetation of Pavant, Round, and Juab Valleys can be made based on the historical descriptions, recollections of early residents, land surveys, and observations of relict undisturbed plant communities presented.

Although there is variation among the various descriptions made by the explorers and early residents of Pavant, Round, and Juab Valleys, one is impressed more by the similarities than by the variations. There are some exceptions such as the observations of Remy (1861), who viewed the Utah landscape as generally barren, particularly the areas lacking trees. Variations in the descriptions by the early observers were due, in some cases, to the fact that the routes taken by the observers were in different parts of the valleys. The seasons of the year also accounted for some variation in description of the areas. It is apparent that personal factors would also account for some differences in observation.

A study of the historical sources and field observations indicates that the plant communities occurred more or less in belts along the contours of the valley slopes. It is apparent that the foothills were covered with grasses, scattered junipers (*Juniperus utahensis*), and sagebrush (*Artemisia tridentata*). The grass of this region has been called "bunchgrass" and, doubtless, it refers principally to *Agropyron spicatum* and *Poa secunda*. In level areas among the foothills western wheatgrass (*Agropyron smithii*) was common. This grass species (locally called "bluegrass") forms a heavy sod and is one species that was sometimes cut for hay. The former abundance of grasses in the juniper woodland of foothills of the mountain ranges in western Millard County was pointed out by Stewart, Cottam, and Hutchings (1940, p. 313), and a list of characteristic grass species of the community was presented, the most important being bluebunch wheatgrass. Western wheatgrass was not included in the list from western Millard Co. Stewart, Cottam, and Hutchings observed (p. 312) that species of sagebrush "are the principal understory shrubs, with big sagebrush occupying the alluvial deeper soils and black sagebrush dominating shallow rocky ones." Seven other shrubs were listed as frequently encountered species.

Below the foothill region and on the more gentle slopes leading into the valley bottoms there were extensive areas of grass. This grassy zone appears to have varied from one to several miles in width. Sagebrush was common and in some places probably was the most conspicuous species present. The grass community growing in this region was composed of the same species as those on the foothills. This grassy area graded into a zone where sagebrush was definitely the most conspicuous plant. It should be emphasized that "sage" and "sagebrush" as used by early explorers and pioneers does not always mean *Artemisia tridentata*. It seems apparent that such plants as white sage,

Eurotia lanata, and shadscale, *Atriplex confertifolia*, were often lumped with the true *Artemisia* under the designation "sage" or "sagebrush."

The upper parts of this brush area must have contained considerable grass since in the old survey reports of some townships in which only sagebrush was listed, the general statement was made that the areas were excellent for grazing. Stewart, Cottam and Hutchings (1940, p. 300) have determined that in the valleys of western Millard County grasses "were originally important members of practically all" of the desert-shrub communities and that "big sagebrush and black sagebrush (black sage), with abundant grasses interspersed, dominated the foothills." This is certainly similar to the situation in valleys of eastern Millard and Juab Counties considered in this paper. Stands of white sage and bud sage, *Artemisia spinescens*, grew in this zone. An area just north of Holden is currently called "Whitebush" because of the white sage that formerly grew in the area. (In 1962 the authors could find only one white sage plant in this area.)

Lower in the valleys, below the sagebrush zone, wet meadow lands occurred. Greasewood stands, sagebrush communities, and other northern desert shrub types also occurred in the lower portions of the valleys. Sand dunes with very sparse vegetation occurred in the western part of Pavant Valley. The historical information of these communities is limited. Most of the routes of travel were through the grass and grass-sagebrush communities near the eastern parts of the valleys, and consequently little was written about northern desert shrub types.

The larger streams were apparently well wooded, at least in the vicinity of the foothills.

VEGETATIONAL CHANGE

Grass-Sagebrush Communities. The vegetation of the valleys has changed considerably in the last 100 years. Great change has occurred in the grassy zone at the base of the foothills. Much of this area is under cultivation today. Cultivation of these areas was begun in most of the region between 40 and 50 years ago. It is used largely for raising dry land wheat. The change from native perennial vegetation to cultivated wheat is drastic, but it is interesting to note that other significant changes occurred before cultivation was begun. Many of the people now living in the small town of East Millard remember the time when dry land farming increased greatly in acreage in the Pavant Valley. They remember that most of the land was plowed out of sagebrush. Men that are 70 years old remember this region as being a sagebrush zone and not one of grass. Similarly, Cardon (1913) recorded the change from grass to sagebrush from 1863 to 1903 in Juab Valley. In 1911, Meinzer described the "large and luxuriant sagebrush" on the alluvial slopes of the area (p. 24). The transition from a predominance of perennial grass and increase of sagebrush prior to cultivation is well documented. The major decline of grass and increase of sagebrush probably occurred between 1870 and 1900. In this century, several exotic species have become important components of the vegetation (Pickford 1932, Christensen 1962, 1963a, b).

In the 1870's the pasturage of Pavant Valley must have been abundant since during this time large herds of livestock were brought from as far as Salt Lake City to graze the good grass of the valley according to the recollection of Hyrum Bevan Johnson (1947). After this time references are made to the diminishing quantity of forage. Livestock census reports indicate that there was a great increase in grazing pressure during this period (Richan, 1957).

In 1887 Samual Pitchforth writing to the *Deseret News* related that there were "hundreds of thousands of sheep roaming the hills and finding pasturage in the rich mountains" of the southern counties and that "year after year their number increases." He stated that "Juab County is a natural winter range for sheep, and within the immediate vicinity of Nephi there are 200,000 sheep wintered" (Worthington 1958, pp. 60-61). After the arrival of the railroad in 1879, Nephi became the shipping point for wool, cattle, and sheep, the latter being driven from southern Utah ranges.

Changing range conditions in Pavant Valley were indicated by two articles appearing in the *Deseret News*, January 18, 1871, and August 11, 1875 (Richan, 1957):

> January 18. All the sheep are taken from the settlements in the summer season on to high mountain ranges heretofore not pastured, thus leaving the grass in the vicinity of our settlements for cows and work animals.
>
> August 11. The long-eared denizens of the sagebrush have taken about one half of the wheat crop of this country, they, the rabbits being unreasonably fond of the "staff of life"

> and owing to the drouth, all kinds of grain crops will be light. Taking the above dark outlook in connection with the fact that our cattle range has dried up and blown away, i.e., the small amount left by the imported root pullers of Texas, with a light crop of hay, and nothing to export. . . . Our fruit crop is among the things not to be recorded as a failure as it has never been surpassed in this place.

Bracken (1940) stated that in 1851 when Juab Valley was settled the valley floor was covered with western wheatgrass, but following 1881, "the grass was so severely over-grazed that it was largely replaced by sagebrush."

Jack rabbits may have aided greatly in the deterioration of the grasslands. It seems that their population must have reached a peak during this same period (1880-81). Ashby (1955-56, p. 89) relates:

> Rabbits were very thick everywhere, and there was nothing for them to eat. They gnawed the sage brush down to stumps. They came into town, into the yards of the people, and ate almost everything in sight. Cedar posts had the bark eaten off in a circle where the rabbits could reach. Trees were barked and hay stacks, where not protected, were undermined.

Invasion by Juniper. An invasion of juniper into the original grass and sagebrush zones has occurred. This invasion was particularly well documented in Pavant Valley. Juniper was common in Pavant Valley in the days of the early pioneers. Written records indicate an adequate supply of "cedar" fuel along the valley's eastern border. The descriptions of P. P. Pratt (Stanley and Camp 1935, Richan 1957) and Jules Remy (1861) indicate that the juniper stands must have been mostly rather open and of mature age. Although some small patches of the old junipers may have been located in lower parts of the valley, most of the junipers were restricted to the hills, but not in dense stands as they are today.

The extent of the invasion by juniper was determined by comparing the vegetation descriptions of 1870 survey lines with the vegetation currently growing along those lines which have not been cultivated. In T20S, R4W the line between sections 30 and 31 was described as being covered with grass with sagebrush. Now young junipers and oaks are very prominent along this line. Between sections 16 and 21 of T21S, R4W, sagebrush was listed as the vegetation type in the survey records. This line is now covered with juniper. General observations indicate that junipers are reproducing rapidly in both the areas of invasion and in the old stands of juniper. A similar invasion of juniper has occurred in the Pine Valley Mountains of southwestern Utah (Cottam and Stewart, 1940), in Pine Valley and Wah Wah Valley in western Utah (Stewart *et al.* 1940, Cottam 1947), and in the valleys of Tooele County (Cottam 1961b).

The grass cover of the foothills has been greatly reduced, and the sagebrush and juniper have become more abundant in the foothill zone.

Sand Dune Migration. Sand movement in the lower portions of Pavant Valley has changed and modified the local plant communities. The sand dunes west of Holden in T19S, R5W were studied to determine migration rates. Several groups of dunes are located within the township. The dunes considered in this discussion are located in sections 25, 26, and 27.

Methods of calculating the extent of movement are rough, but different measurements give results of the same magnitude. The sand in this region drifts in a northeast direction due to the prevailing winds from the southwest. Maps of the 1944 soil survey of East Millard and the vegetation and soil map constructed from the 1869-70 land survey were used to determine the rates of movement. The migration from 1957 to 1962 was observed by the authors. The survey of 1870 shows that the forward dunes of the group now in section 27 were then at the southwest corner of section 27, and the ones now in section 25 were at the southwest corner of section 25. The migration rates vary between 50 and 66 feet per year, with the long term rates being 53.5 and 60.9 feet per year (Table 2). This rate of migration is over twice as great as that reported for disturbed dunes in Pine Valley in western Utah by Stewart *et al.* (1940).

The invasion of tamarix (*Tamarix pentandra*) into the lowland areas of the valleys since 1925 is a conspicuous feature of the vegetational change of the valleys (Christensen 1962). The naturalization of tamarix has occurred in a striking manner on the sand dunes of Pavant Valley. This species has helped to reduce the movement of the sand in recent years.

Table 2

MIGRATION OF SAND DUNES IN PAVANT VALLEY, 1870-1962

Dunes in Section 27 *Years*	*Elapsed Time*	*Total Movement*	*Yearly Average*
1870-1944	74	4,290	58.0 ft
1870-1962	92	5,610	60.9 ft.
1944-1962	18	1,190	66.0 ft.
1957-1962	5	250	50.0 ft.
Dunes in Sections 26 and 25			
1870-1944	74	3,960	53.5 ft.

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